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FINAL SUPPLEMENT
TO THE

DRAFT WEST-CENTRAL NORTH DAKOTA REGIONAL ENVIRONMENTAL IMPACT STUDY ON ENERGY DEVELOPMENT

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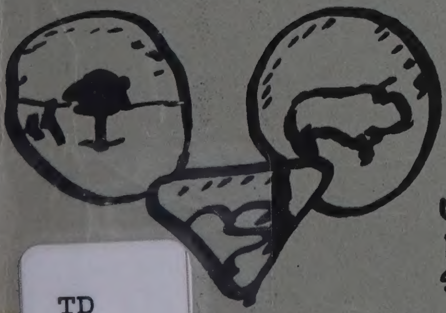

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
STATE OF NORTH DAKOTA

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INTRODUCTION

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INTRODUCTION

The Draft West-Central North Dakota Regional Environmental Impact Study on Energy Development was drafted in September 1977, released to the public in March 1978, and the public review period (which was extended from 75 to 90 days) was completed in June 1978. The large Draft Study was also accompanied by a Summary, and Technical Supplements on economic and social conditions, climate and air quality, land use, and the Fort Berthold Indian Reservation.

Three informational meetings and seven formal public hearings were held throughout the seven counties. After evaluating all comments from letters and trasncript testimonies, it was felt that the comments were helpful and required many changes, but for the most part, substantial changes requiring a complete reprint of the large Draft Study was not necessary. Therefore, this Final Supplement amends the original Draft Study. The Council on Environmental Quality has recently published proposed regulations which say that "if changes are minor and are confined to (factual corrections or explaining why the comments do not warrant a complete reprint), agencies may write them on errata sheets and attach them to the statement instead of rewriting the draft statement. In such cases, only the comments, the responses, and the changes, and not the final statement need be circulated."

This Final Supplement is divided into two parts. Part 1, "Modifications and Corrections," is arranged by environmental components (animals, vegetation, social conditions, proposed action, alternatives, etc.) and includes all changes required by (1) public comments, or (2) other changes desired by the original authors and work groups. These changes include minor technical and editing corrections, clarification, modifications, new information, and revised visuals. Most of what is in Part 1 is also in Part 2, but Part 1 is for the convenience of the reader so that all changes can be

found in one place. Part 2 is arranged by public comments followed by specialist responses (arranged by date, except for duplicates and attachments which are placed as close to the original as possible). Each letter or testimony has number assignments which includes all material between horizontal lines in the right margin. Immediately following each letter, the author responses correspond to the same numbers on the letter. Responses to individual verbal testimonies follow the complete transcript for each public hearing.

There is some duplication caused by letters which supplemented the same person's verbal testimony. This duplication was not eliminated because in some cases (1) the written letter was more accurate than the verbal testimony, (2) the letter or testimony included additional information, and (3) the verbal testimony included panel discussion. Also, the 11 repetitious introductions from the public hearings were not eliminated because of the paginated certified transcripts, and because we did not wish to tamper with public comments in any way.

Some opinions were not addressed, but wherever possible, answers were given. Some of these answers, however, did not affect conclusions in the original Draft Study, therefore, were not included in Part 1. Some of the comments were from readers who read only the Summary or only read portions of the Draft Study. Some of the responses are short, refer to other numbers and sections, and may be awkward because of various specialists' responses being integrated into one response. A smoother, more complete response is usually included in Part 1 if amendments were made.

Minor changes on visuals are simply listed. Page size visuals which were reprinted are included in Part 1.

Approximately 1,000 copies of Map 2-42, "Recreation Resources," Map 2-49, "Transmission Systems," and Map 2-36, "Endangered Species" are available through the EIS Office in Bismarck or BLM Office in Billings.

The objective of this Final Supplement was to (1) update the Draft Study, (2) note where changes were impossible, and (3) address each comment. A necessary assumption was that the proposed action as originally specified had not changed. The proposed actions, and laws, have and will continue to change; but the subject of a study is not changed just because the conclusions or laws change. This study is not a document upon which final decisions will be made. It is however, a base from which better planning can be done. The State of North Dakota indicates that they consider the study to be the single most comprehensive document on energy development in the state and a valuable reference source. The document is expected to be used or has already been used to identify areas requiring further study, orientation at legislative conferences, and an information source for the public on the future potentials of coal development within the state. It is also expected to be used as input into the state coal leasing program, state reclamation program for determining lands unsuitable for coal mining, state planning activities related to energy development, and in determining potential coal development and supplies.

Major changes or clarification as a result of public comments included the following:

(1) Additional information and recent amendments in climate and air quality sections.

(2) Growth in Stark, Billings, and Dunn Counties.

(3) Exclusion/avoidance areas.

(4) Surface owner consent.

(5) Trends in surface owner choices of reclamation.

(6) NGPL.

(7) Reregulation dams.

(8) Social methodology.

(9) Oil fields.

(10) Endangered species.

(11) Mined land reclaimability.

(12) Public health.

In some cases, more cannot now be projected. One purpose of any study is to keep questions ongoing. The North Dakota Regional Environmental Impact Study is not formally an environmental impact statement (EIS), however, a major objective of the study is to comply with the intent of the National Environmental Policy Act (NEPA) in apprising decision-makers on the cumulative effects of proposals requiring federal and state actions. In addition, the public review program for the study was designed to solicit and evaluate comments from involved publics including formal public hearings in conformity with the public review goals of NEPA. It was never intended that the regional study replace the formal state or federal permit or environmental assessment requirements on specific proposals. These will be dealt with on a case-by-case basis or program basis according to individual agency procedures. Hopefully the regional environmental study will provide useful information for these specific proceedings or EISs and provide evaluation with a better understanding of their broad regional implications. A revised federal coal management program is currently

being developed by the US Department of Interior including the preparation of a nationwide programmatic environmental impact statement. Formal NEPA compliance regarding the leasing or management of federal coal must be consistent for the requirements of that policy once it is developed and issued. It is unlikely that duplicate regional environmental impact statement would be issued simply to comply with formal NEPA procedures. Instead it is more likely that NEPA requirements related to federal coal will build upon the analysis already inherent in the regional impact study were applicable and will expand upon this analysis where necessary. Since there is no administrative machinery for developing a federal-state local proposed energy development plan for a geographic area, the regional impact study did use industry plans, circumscribed by specific federal-state standards, as the basis for its cumulative assessment. This evaluation will be used in the completion of a seven county land use analysis by the Bureau of Land Management, culminating in coal leasing and management decisions consistent with the new program now being developed.

Therefore, no long term federal leasing will resume in North Dakota until that plan is complete and a specific decisions in that plan are covered under formal environmental impact statements or assessments on a site specific or cumulative basis as appropriate.

PART 1

MODIFICATIONS & CORRECTIONS

CLIMATE AND AIR QUALITY

INTRODUCTION

The importance of air quality to the citizens of North Dakota was evident in hearing testimony and the written comments submitted concerning the Draft Study. The interest shown in protecting North Dakota's air quality and related quality of life factors, as well as the time and effort these people put into reviewing the Draft Study, was evident in their review comments.

A need was expressed for updating the Draft Study to take into account the Federal Clean Air Act Amendments of 1977. This major piece of legislation was passed about the same time the Draft Study went to press and hence, it was not considered in the analysis of the proposed projects. The separate Climate and Air Quality Technical Supplement, which was written in December of 1977, did provide additional updated information; however, this document is no longer current. Full implementation of the provisions of the Clean Air Act Amendments of 1977 will continue to change, with time, probably through the 1980s. Updated information on the Clean Air Act Amendments, through October 1978, is now included.

Concerns were expressed over the magnitude of total emissions from the proposed Level 1 and Level 2 projects through their expected lifetime of operation. The magnitude of total emissions is indeed large. These emission totals, while providing emphasis on the atmospheric loading of pollutants, cannot be directly used to determine the extent of effect upon the environment of the seven county study area. Effects upon the environment are determined from the ground level concentration of pollutants which result from these emissions.

The Draft Study made a number of summary references to the increase in air pollutant concentrations from Level 1 and Level 2 projects, "being well within the State Ambient Air Quality Standards which are equal to or more stringent than the Federal Standards." Although numerical comparisons were presented in Chapter 3 of the Draft Study, which demonstrated this fact, concerns were expressed questioning the adequacy of standards. These concerns are justified in view of news reports of Congressional testimony which noted air pollution effects occurring at pollutant concentrations below the National Ambient Air Quality Standards. Assuming that the studies referenced in this testimony are correct, the projected environmental concentrations of pollutants from Level 1 and Level 2 projects were compared and found to be less than the concentrations noted to cause problems. This is reviewed in more detail in the updated discussion on air pollution effects.

The effects of air pollution, in general, were referenced by a number of persons. Concerns included human and animal health; effects upon vegetation; long-term effects of trace elements; acid rain and radiation impacts; and effects upon materials, visibility, and weather. This Final Supplement takes these concerns into consideration and each environmental factor is discussed under "Air Pollution Effects."

The increase in ambient air quality concentrations resulting from Level 1 and Level 2 project emissions were evaluated in terms of expected effects upon the environment. The maximum impact area from Level 1 and Level 2 sources is projected to occur in Mercer and Oliver Counties, within eight miles of Beulah. No perceptible effects upon the environment are expected to occur in this maximum impact area, the broader area of the seven county region, or in the

Fort Berthold Reservation, as a result of emissions of Level 1 and Level 2 sources.

The Draft Study focused on coal development in a seven county area in western North Dakota. It was quite appropriately recognized by a number of persons that effects upon air quality are not confined to political boundaries or only to coal development. Oil and gas development, which is occurring in western North Dakota within and beyond the seven county region, will influence the location and magnitude of future coal development in this state. This is also discussed in more detail herein.

Many studies have been conducted within the seven county study area to evaluate the impacts of individual energy development facilities. This includes site-specific environmental impact statements, which have added to the knowledge of effects upon the environment from energy development. Although the effects upon the environment from Level 1 and Level 2 projects are not expected to result in adverse effects upon the environment, a better understanding of the environment of western North Dakota is indicated.

Other subjects of concern included trace elements, environmental radiation, acid rainfall, and synergistic effects of air pollution. The need for expansion of the environmental effects knowledge base is appropriate as it could influence future energy development in western North Dakota beyond the Level 1 and Level 2 projects. Answers to these environmental questions will determine where and how much development will be allowed in western North Dakota.

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FEDERAL CLEAN AIR ACT AMENDMENTS OF 1977

The Federal Clean Air Act Amendments of 1977 were signed into law on August 7, 1977. The writing of the Draft West-Central North Dakota Regional Environmental Impact Study on Energy Development was completed about this same time. Therefore, many implications of the Federal Clean Air Act Amendments could not be considered. The Climate and Air Quality Technical Supplement, which was prepared in December of 1977, did discuss Prevention of Significant Deterioration of Air Quality, one of the major issues addressed in the Clean Air Act Amendments. However, regulations fully implementing this portion of the Clean Air Act Amendments were not promulgated by the U.S. Environmental Protection Agency until June 19, 1978. Applicable laws and subsequent rules, regulations, and standards change, thus requiring frequent updates of information.

The Clean Air Act Amendments of 1977 have had a dramatic influence on the climate and air quality portion of the Draft Study. One of the major considerations addressed was the Prevention of Significant Deterioration of Air Quality. This legislation established a detailed system of area classifications and air quality increments designed to protect air quality in areas which had cleaner air than that established by the National Ambient Air Quality Standards. Other provisions of this law affecting Level 1 and Level 2 projects include a more stringent definition of Best Available Control Technology; and recognition of the need for re-examination of the current National Ambient Air Quality Standards, both for the appropriateness of these standards and the pollutants included.

Ambient Air Quality Standards

The EPA, under the Clean Air Act Amendments of 1970, was required to establish National Ambient Air Quality Standards for air pollutants. National primary standards to protect health and secondary standards to protect public welfare were promulgated for six pollutants. The six pollutants are sulfur oxides (sulfur dioxide), particulate matter, carbon monoxide, photochemical oxidants, hydrocarbons, and nitrogen dioxide (see Table 1). The states, under this law, can adopt and promulgate their own ambient air quality standards as long as they are equal to or more stringent than the Federal Ambient Air Quality Standards promulgated by the EPA. The North Dakota State Department of Health promulgated Ambient Air Quality Standards for the State of North Dakota. The State standards are equal to or more stringent than the Federal secondary standards for the six federal pollutants. In addition, the state has also adopted standards for settled particulates, coefficient of haze, reactive sulfur, suspended sulfates, sulfuric acid mist and sulfur dioxide, and hydrogen sulfide.

The purpose of the North Dakota Ambient Air Quality Standards is to control the quality of the air over North Dakota such that, (a) the health of sensitive or susceptible segments of the population will not be adversely affected; (b) concentrations of pollutants will not cause public nuisance or annoyances; (c) significant damage to animals, ornamental plants, forest and agricultural crops will not occur; (d) visibility will not be significantly reduced; (e) metals or other materials will not be significantly corroded or damaged; (f) fabrics will not be soiled, deteriorated, or have their colors affected; and (g) natural scenery will not be obscured. The North Dakota Ambient Air Quality Standards are presented in Table 2.

TABLE 1

FEDERAL PRIMARY AND SECONDARY AIR QUALITY STANDARDS

Air Contaminant	Averaging Time	Federal Primary Standard	Federal Secondary Standard
Nitrogen Dioxide[1]	Annual Average	100 $\mu g/m^3$ (0.05 ppm)	100 $\mu g/m^3$ (0.05 ppm)
Sulfur Dioxide	Annual Average	80 $\mu g/m^3$ (0.03 ppm)	---
	24-Hour	365 $\mu g/m^3$ (0.14 ppm)	---
	3-Hour	---	1,300 $\mu g/m^3$ (0.5 ppm)
Suspended Particulate	Annual Geometric Mean	75 $\mu g/m^3$	60 $\mu g/m^3$
	24-Hour	260 $\mu g/m^3$	150 $\mu g/m^3$
Hydrocarbons (corrected for Methane)	3-Hour 6-9 A.M.	160 $\mu g/m^3$ (0.24 ppm)[2]	160 $\mu g/m^3$ (0.24 ppm)
Photochemical Oxidants	1-Hour	160 $\mu g/m^3$ (0.08 ppm)	160 $\mu g/m^3$ (0.08 $\mu g/m^3$)
Carbon Monoxide	8-Hour	10 mg/m^3 (9 ppm)	10 mg/m^3 (9 ppm)
	1-Hour	40 mg/m^3 (35 ppm)	40 mg/m^3 (35 ppm)

SOURCE: 40 Code of Federal Regulations Part 50, July 1, 1976

NOTE: ppm = parts per million

$\mu g/m^3$ = micrograms per cubic meter

mg/m^3 = milligrams per cubic meter

[1] Nitrogen dioxide is the only one of the nitrogen oxides considered in the ambient standards.

[2] Maximum 3-hour concentration between 6-9 A.M.

TABLE 2

STATE OF NORTH DAKOTA AIR QUALITY STANDARDS

Air Contaminant (Units)	Averaging Time	Maximum Permissible Concentration
Total Suspended Particulates ($\mu g/m^3$)[1]	Annual Geometric Mean	60
	24-hour	150[2]
Settled Particulate - Dustfall (tons per Square mile per month)	3-month	15[3]
	3-month	30[4]
Coefficient of Haze (Coefficient of Haze per 1,000 linear feet)	Annual Geometric Mean	0.4
Sulfur Dioxide ($\mu g/m^3$)	Annual Average	60
	24-hour	260
	1-hour	715
Reactive Sulfur ($mg/100cm^2/day$)[5]	Annual Average	0.25
	1-month	0.50
Suspended Sulfates ($\mu g/m^3$)	Annual Average	4
	24-hour	12[6]
Sulfuric Acid Mist, Sulfur Trioxide or Combination ($\mu g/m^3$)	Annual Average	4
	24-hour	12[6]
	1-hour	30[6]
Hydrogen Sulfide ($\mu g/m^3$)	1/2-hour	45[7]
	1/2-hour	75[8]
Carbon Monoxide (mg/m^3)[9]	8-hour	10[2]
	1-hour	40[2]
Photochemical Oxidants ($\mu g/m^3$)	1-hour	160[2]
Hydrocarbons ($\mu g/m^3$)	3-hour (6-9 a.m.)	160[2]
Nitrogen Dioxide ($\mu g/m^3$)	Annual Average	100
	1-hour	200[10]

SOURCE: North Dakota State Department of Health Air Pollution Control Regulations, 1976

1/ $\mu g/m^3$ is the abbreviation for micrograms per cubic meter.
2/ Maximum not to be exceeded more than once per year.
3/ Maximum in a residential area.
4/ Maximum in an industrial area.
5/ $mg/100cm^2/day$ is the abbreviation for milligram sulfur trioxide per 100 square centimeters per day.
6/ Maximum not be be exceeded over 1% of the time.
7/ Maximum not to be exceeded more than twice in any five consecutive days.
8/ Maximum not to be exceeded over twice a year.
9/ mg/m^3 is the abbreviation for milligrams per cubic meter.
10/ Maximum not to be exceeded over 1% of the time in any 3-month period.

Generally, North Dakota's air quality is considerably better than the National Ambient Air Quality Standards. That is why the State Department of Health adopted ambient air quality standards in May of 1970 equal to the Federal secondary standards (the more stringent of the Federal standards) for total suspended particulates, carbon monoxide, photochemical oxidants, and hydrocarbons. With respect to sulfur dioxide and nitrogen dioxide, the state adopted standards which were more stringent than the Federal requirements. Prior to adoption of State Ambient Air Quality Standards, EPA air quality criteria (cause and effect) documents were reviewed. Since North Dakota's air quality is better than that addressed by Federal standards and in the absence of anti-degradation or prevention of significant deterioration legislation in 1970, the Department felt it prudent to adopt standards which were equal to the most stringent Federal standard or, as in the case of sulfur dioxide and nitrogen dioxide, a more stringent standard.

Testimony before Congress, in its consideration of amendments to the Clean Air Act of 1977, raised a number of questions including the adequacy of existing National Ambient Air Quality Standards, the limiting of the Federal standards to six pollutants, and the relative absence of standards addressing synergistic effects, trace metals, particle size, and derivative chemicals. These questions arose as a result of the introduction of study reports and testimony indicating the occurrence of environmental effects at air quality levels below the National Ambient Air Quality Standards. A more detailed discussion of cause and effect relationships related to the Level 1 and Level 2 projects is presented in "Air Pollution Effects."

Congress, in light of information which it received concening air pollution effects, made a number of revisions to the Clean Air Act Amendments of 1970 related to ambient air quality standards. These revisions included a requirement that the Administrator of EPA complete a thorough review of criteria used in promulgating national ambient air quality standards, make revisions in criteria, and promulgate new standards as appropriate. The first review is to be completed by December 31, 1980, and at five-year intervals thereafter, although the Administrator may review and revise criteria and promulgate new standards more frequently than required. With respect to nitrogen dioxide and derivatives of nitrogen oxides, the Administrator was directed to promulgate a short-term (not more than 3-hour period) standard by August 7, 1978, unless found that there is not significant evidence that such a standard is necessary to protect public health.

Increased emphasis on air quality standards was seen in defining hazardous air pollutants as pollutants for which no ambient air quality standard is applicable and which, in the judgment of the Administrator, causes or contributes to air pollution which may reasonably be anticipated to result in an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness. This is a broadening of the definition found in the Clean Air Act Amendments of 1970. The Clean Air Act Amendments of 1977 specifically mentioned emissions of radioactive pollutants, cadmium, arsenic, polycyclic organic matter, and sulfates.

In general, there was an increased emphasis in the Clean Air Act Amendments of 1977 on review of air quality standards and air quality effects and the need to provide standards to protect public health and welfare. This

emphasis formed the basis for the statutory establishment of the prevention of significant deterioration provisions of the Clean Air Act Amendments of 1977 which provides for limiting pollution increases in areas now cleaner than the National Ambient Air Quality Standards.

New Source Performance Standards

The Clean Air Act Amendments of 1970 provided for the establishment of standards of performance for new stationary sources reflecting the highest degree of air pollutant emission limitations achievable and adequately demonstrated, taking into account the cost of achieving those limitations. The Clean Air Act Amendments of 1977 expanded upon this section of the law by specifically identifying the stationary source category of fossil fuel fired sources. With respect to stationary sources in general (including non-fossil fuel fired sources), the Administrator is to publish a list of categories of stationary sources, which in his judgment, may reasonably be anticipated to endanger public health or welfare. The Administrator is to review, at least every four years, and revise such standards, if appropriate. The definition of the term "standard of performance" was changed to reflect the highest degree of emission limitation and percentage reduction achievable through application of the best technological system of continuous emission reduction which the Administrator of EPA determines has been adequately demonstrated for that category of sources. This determination by the Administrator is to consider the cost of achieving the emission reduction and any non-air quality health and environmental impact and energy requirements.

On September 19, 1978, EPA published Federal Register, Vol. 43, No. 182, page 42154 proposed rules concerning standards of performance for new electric utility steam

generating units. These rules would apply to those units that are capable of firing more than 73 megawatts (250 million Btu/hour) heat input of fossil fuel and for which construction is commenced after September 18, 1978. Since the comment period on this proposed rule ends on November 20, 1978, it is possible that final action will be taken before this supplement is published.

The proposed standards of performance would limit emissions of sulfur dioxide, particulate matter, and nitrogen oxides from new, modified, and reconstructed electric utility steam generating units capable of combusting more than 73 megawatts (250 million Btu/hour) heat input of fossil fuel. The intended effect of this proposal is to require new, modified, and reconstructed electric utility steam generating units to use the best demonstrated systems of continuous emission reduction. This proposed standard of performance is one of many which will be reviewed and possibly revised in the years ahead to satisfy the provisions of the Clean Air Act Amendments of 1977.

PREVENTION OF SIGNIFICANT DETERIORATION OF AIR QUALITY

One of the major actions of the Clean Air Act Amendments of 1977 was to provide a distinct statutory basis for Prevention of Significant Deterioration of Air Quality. The prevention of significant deterioration provisions of the Clean Air Act Amendments of 1977 have had a dramatic influence on Level 1 and Level 2 proposed projects. Although a prevention of significant deterioration review was conducted of Level 1 and Level 2 projects in the Draft Study, the Clean Air Act Amendments of 1977 changed some of the ground rules; thereby imposing additional restrictions upon these projects.

The EPA, in response to a May 30, 1972, court decision (Sierra Club vs. Ruckelshaus), affirmed in 1973 by the Supreme Court, promulgated regulations on December 5, 1974, to prevent the significant deterioration of air quality. The EPA prevention of significant deterioration regulations are effective nationwide because the EPA disapproved all state implementation plans not containing adequate procedures for preventing significant deterioration in any portion of any state where the air is cleaner than the National Ambient Air Quality Standards.

The prevention of significant deterioration program is based on the principle that clean air is a natural resource of great importance and this resource's value cannot always by measured in terms of proven health and property damage. The regulations were the result of a detailed study and extensive public participation, including nationwide public hearings.

North Dakota was one of the first states in the nation to adopt a prevention of significant deterioration regulation. The State Department of Health felt that this regulation had merit because it could protect the air quality of this state which is better than the National Ambient Air Quality Standards. The North Dakota prevention of significant deterioration regulations adopted in January of 1976 were similar to the prevention of significant deterioration regulations promulgated by EPA in December of 1974. On May 26, 1977, EPA delegated responsibility for prevention of significant deterioration to the State of North Dakota.

Prevention of significant deterioration was one of the major issues addressed in the Clean Air Act Amendments of 1977. The legislation established a detailed system of area

classification and air quality increments designed to prevent significant deterioration of air quality in clean air areas. The clean air areas were defined as those in which major pollutants were monitored at levels below the limits established by the National Ambient Air Quality Standards.

According to the Clean Air Act Amendments of 1977, certain prevention of significant deterioration provisions were effective immediately, with others delayed until such time as state implementation plans could be revised. New regulations proposed by the U.S. Environmental Protection Agency on November 3, 1977 (Federal Register, Vol. 42, No. 212) would establish an implementation date of March 1, 1978, for those prevention of significant deterioration regulations which were to have been delayed, pending revision of state plans. Final action on the proposed EPA prevention of significant deterioration regulations was taken on June 19, 1978. North Dakota's prevention of significant deterioration regulations and implementation plan were subsequently revised and took effect on July 1, 1978.

A prevention of significant deterioration analysis of proposed Level 1 and Level 2 projects was done for the Draft Study; however, these projects have been re-examined. The results of this re-examination, in light of the Clean Air Act Amendments of 1977, will be discussed later under "Analysis of Draft Study Proposed Level 1 and Level 2 Projects."

New Source Review Procedures

The prevention of significant deterioration regulations, in effect prior to enactment of the 1977 Amendments, identified 19 major stationary source categories as subject to prevention of significant deterioration preconstruction

review procedures under EPA regulations. Twenty-one major stationary source categories were included in the then existing North Dakota regulations. The new Amendments expand these to include 28 major stationary source categories with the potential to emit more than 100 tons per year of any regulated pollutant. Also included are any sources with the potential to emit 250 tons per year of any regulated pollutant.

A more stringent definition of Best Available Control Technology is now required for all sources subject to the prevention of significant deterioration regulations. The Clean Air Act Amendments of 1977 include provisions for pollutants other than those for which National Ambient Air Quality Standards have been set (the six criteria pollutants). Best Available Control Technology will also be required for modifications or expansions of existing sources, if such sources are included among those specified by the legislation as being subject to prevention of significant deterioration requirements.

Best Available Control Technology is defined in the current North Dakota prevention of significant deterioration regulations as an emission limitation (including a visible emission standard) based on the maximum degree of reduction of each contaminant subject to regulation emitted from any major stationary source or major modification, which the Department of Health on a case-by-case basis (taking into account energy, environmental, and economic impacts and other costs) determines is achievable for such source or modification. In no event shall application of "best available control technology" result in emissions of any pollutant which would exceed the emissions allowed by any applicable standard of performance. If the Department determines that technological or economic limitations on the

application of measurement methodology to a particular class of source would make the imposition of an emission standard infeasible, the Department may instead prescribe a design, equipment, work practice, or operational standard, or combination thereof, requiring the application of best available control technology. Such standard shall, to the degree possible, set forth the emission reduction achievable by implementation of such design, equipment, work practice, or operation, and shall provide for compliance by means which achieve equivalent results.

The prevention of significant deterioration review process allows opportunity for a public hearing before a final decision is made by a state regulatory agency on awarding of the permit. Applications for permits after August 7, 1978, by sources subject to prevention of significant deterioration review must be accompanied by an analysis of one year continuously measured air quality data for all criteria pollutants. Monitoring will not be required for nonmethane hydocarbons and for sources for which the increased potential emissions would not exceed 50 tons per year.

Preconstruction review requirements, as outlined above, would apply to any source which did not obtain a final prevention of significant deterioration permit before March 1, 1978. The EPA regulations state: "It is important to note that EPA's current prevention of significant deterioration regulations contemplate at least a 90-day period from completed application submission to permit issuance. Accordingly, sources which had not filed completed applications by December 1, 1977, should not assume that a final permit approval will be issued by March 1, 1978, and should therefore plan to be reviewed under the new rules." Sources obtaining final permit

approval prior to the March 1 deadline, but not commencing construction before December 1, 1978, would also be subject to the prevention of significant deterioration review requirements.

Class I Areas in North Dakota

The Clean Air Act Amendments of 1977 set forth "effective immediately" more restrictive maximum allowable ambient air increments for particulate matter and sulfur dioxide in Class I, Class II, and Class III areas (see Table 3). Also, immediately effective is the requirement that each National Ambient Air Quality Standard (not just particulate matter and sulfur dioxide) shall act as an overriding ceiling to any otherwise allowable increment. It also provides that for any period other than any annual period, the applicable increment may be exceeded only during one such period per year at a given site.

Certain areas were classified on August 7, 1977, as Class I by Congress and thus are subject to the most stringent restraints on air quality deterioration. These areas include all international parks, all national wilderness areas which exceed 5,000 acres in size, all national memorial parks which exceed 5,000 acres in size, and all national parks which exceed 6,000 acres in size. This designation applies only to areas which were in existence on the date of enactment of the Clean Air Act Amendments of 1977. These areas may not be redesignated. In North Dakota, these areas include the Lostwood National Wilderness Area, a 5,577-acre area in the northwest corner of the Lostwood National Wildlife Refuge in Burke County; and the 69,675-acre Theodore Roosevelt National Memorial Park (which is now called the Theodore Roosevelt National Park).

TABLE 3

NEW PREVENTION OF SIGNIFICANT DETERIORATION OF AIR QUALITY INCREMENTS AND CEILINGS CLEAN AIR ACT AMENDMENTS OF 1977

Pollutants	Maximum Allowable Increase[1/] (in micrograms per cubic meter)		
	Class I	Class II	Class III
Particulate Matter			
Annual Geometric Mean	5	19 (10)[2/]	37
24-hour Maximum	10	37 (30)	75
Sulfur Dioxide			
Annual Arithmetic Mean	2	20 (15)	40
24-hour Maximum	5	91	182
3-hour Maximum	25	512	700

SOURCE: Clean Air Act Amendments of 1977
Title I, Part C, Section 163
August 7, 1977

[1/] Maximum allowable increases over baseline concentrations not to be exceeded more than once per year except for annual where allowable increase over baseline may not be exceeded.

[2/] The numbers in parenthesis ( ) are the corresponding State allowable increments.

Class III Provisions

Another immediately effective change involves three provisions concerning the redesignation of areas to Class III. First, certain areas cannot be reclassified as a Class III area. These include: (1) an area which exceeds 10,000 acres in size and is a national monument, a national primitive area, a national preserve, a national recreation area, a national wild and scenic river, a national wildlife refuge, a national lakeshore and seashore; and (2) a national park or national wilderness area established after the date of enactment of this Act which exceeds 10,000 acres in size. Second, before any area may be redesignated to Class III, specific approval must be received from the Governor, after consultation with the Legislature, and from the local governments representing a majority of the residents in the area which is to be redesignated. Finally, a Class III redesignation must not itself cause or contribute to concentrations of any air pollutant which exceeds the maximum allowable increase in another area.

Attainment and Nonattainment Areas

The sources subject to prevention of significant deterioration review shall continue to be reviewed in both attainment (air quality meets the National Ambient Air Quality Standards) and nonattainment (air quality in excess of National Ambient Air Quality Standards) areas regarding their long-range impact on an increment in any affected area. Also, best available control technology for sulfur dioxide and particulate matter is still required at any location. However, prevention of significant deterioration sources are not subject to any ambient air review for prevention of significant deterioration increments or National Ambient Air Quality Standards ceilings and regards the nonattainment area itself. In this regard, the "Emission Offset" Interpretative Ruling (40 CFR 55524,

December 21, 1976) continues to control the construction of sources which cause or contribute to air quality concentrations in excess of any National Ambient Air Quality Standard. In North Dakota, there are no areas classified as nonattainment areas.

Stack Height Limitations

The Clean Air Act Amendments of 1977 limits stack height for dispersion of emissions to good engineering practice, which is defined as that height necessary to avoid atmospheric downwash, wakes, and eddies. It indicates that good engineering practice should generally not exceed two and one-half times the height of the source (subject to exemption based on appropriate showing by the source).

Computer Dispersion Modeling

The Clean Air Act Amendments of 1977 state that the owner or operator of any proposed source or modification of an existing source must demonstrate that allowable emissions increases from the source or modification, in conjunction with all other applicable emissions increases or reduction, will not cause or contribute to air pollution in violation of any national ambient air quality standard in any air quality control region; or any applicable maximum allowable increase over the baseline concentration in any area.

All estimates of ambient concentrations required, as mentioned above, shall be based on the applicable air quality models, data bases, and other requirements specified in the "Guidelines on Air Quality Models" (OAQPS No. 1.2-080, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina 27711, April 1978). Where an air quality impact model specified in the "Guidelines on Air Quality Models" is inappropriate, the model may be modified or other

models substituted. A substitutional modification of a model shall be subject to public comment procedures. Written approval of the administrator must be obtained for any modification or substitution. Methods like those outlined in the "Workbook for the Comparison of Air Quality Models" (OAQPS No. 1.2-097, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina 27711, April 1977) should be used to determine the comparability of air quality models (source: Federal Register Volume 43, No. 118, page 26386, Monday, June 19, 1978).

The preceding Federal Register Regulations referenced were promulgated by EPA to give some guidance in selecting modeling techniques and types of models in reviewing new sources by state and federal air pollution control agencies. It was the intent of the Clean Air Act Amendments of 1977 to give this guidance for uniformity because of the widespread use of models and modeling techniques by the private sector as well as state and federal air pollution control agencies. In essence, a standardization of all modeling procedures was mandated by the Clean Air Act Amendments of 1977.

A complete reference of the guideline series for air quality models is given below:

> Guideline on Air Quality Models, U.S. Environmental Protection Agency, Office of Air and Waste Management, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina 27711 (EPA-450/2-78-027, OAQPS No. 1.2-080), April 1978.
>
> Workbook for Comparison of Air Quality Models, EPA, Office of Air and Waste Management, Office of Air Quality Planning and Standards, Monitoring and Data

Analysis Division, Research Triangle Park, North Carolina 27711 (EPA-450/2-78-0282, OAQPS No. 1.2-097), May 1978.

Workbook for Comparison of Air Quality Models - Appendices, EPA, Office of Air and Waste Management, Office of Air Quality Planning and Standards, Monitoring and Data Analysis Division, Research Triangle Park, North Carolina 27711 (EPA-450/2-78-0286, OAQPS No. 1.2-097A), May 1978.

Table 4 outlines the models discussed in the guideline documents mentioned above. Footnote 1/ on Table 4 shows the models primarily used in the North Dakota State Department of Health modeling program. Footnote 2/ shows the additional models used in the updating of the Draft Study to demonstrate the impacts of the Clean Air Act Amendments of 1977. The CRSTER and RAM models were not available when the Draft Study was originally prepared. These models allowed a more detailed analysis of the impacts from the proposed Level 1 and Level 2 projects; particularly as these sources impact the reclassified Class I areas (specifically the Theodore Roosevelt National Park).

For a detailed description of the implication of the reclassified Class I areas, the modeling predictions and the overall impacts of the Clean Air Act Amendments of 1977 resulting from Level 1 and 2 projects, see "Analysis of the Draft Study Proposed Level 1 and Level 2 Projects."

Prevention of Significant Deterioration - Variance

If a proposed source cannot satisfy the maximum allowable deterioration increments for a Class I area (see Table 3), an opportunity is afforded to the owner or operator of this proposed source to seek a variance. Three

TABLE 4

AIR QUALITY MODELS CONTAINED ON THE UNAMAP COMPUTER MAGNETIC TAPE

Modeling Program Guide	Use
APRAC	urban model for vehicle-generated pollutants
Climatological[1] Dispersion Model (CDM)	an annual, seasonal urban model--can be modified for rural use
CDMQC	version of CDM with addition of source contribution output
CRSTER[1] [2]	model for estimating maximum 24-hr concentrations during a one-year period from a single rural plant
HIWAY	short-term multi-receptor roadway model
PAL	a short-term multi-receptor model for multi-point, area, and line sources
PTMAX, PTDIS[1]	Two short-term models for a single source in open country
PTMTP[1]	a short-term model for multiple sources and receptors
VALLEY	a model for estimating the upper limits of 24-hr concentrations from a single source in rural complex terrain
RAM[1] [2]	a short-term urban model for point and area sources.

SOURCE: National Technical Information Service
Computer Products Office
5285 Port Royal Road
Springfield, Virginia 22161
Phone: 703-557-4763
PB 277-193

[1] Models commonly used within the North Dakota State Department of Health.

[2] Models which were not available at the time the Draft Study was prepared.

possible variance routes are open to such a source. These would involve the federal land manager of the Class I area, the Governor of the state, and possibly the President of the United States.

The owner or operator of a proposed source may demonstrate to the federal land manager that the emission from the source will have no adverse impact on the air quality related values of the Class I area (including visibility), although the change in air quality resulting from source emissions will cause or contribute to concentrations which exceed the maximum allowable increases for a Class I area. If the federal land manager concurs with the demonstration and he so certifies to the State Department of Health, the Department may issue a restricted permit to construct provided the applicable requirements of the prevention of significant deterioration regulations are otherwise met. Restrictions on this type of permit to construct would include a requirement that the source comply with such emission limitations as may be necessary to assure that emission of sulfur dioxide and particulate matter will not exceed the maximum allowable increased over the baseline concentrations for such pollutants shown in Table 5.

A variance from the maximum allowable sulfur dioxide Class I increments shown in Table 3 could be granted by the Governor, with the federal land manager's concurrence. If a request for a variance cannot be approved by the federal land manager, the owner or operator of the proposed source may submit a demonstration to the Governor, after notice and public hearing, that the source cannot be constructed by reason of any maximum allowable increase for sulfur dioxide for periods of 24 hours or less applicable to any Class I area. In the case of Federal mandatory Class I areas, it must also be demonstrated that a variance under this clause

TABLE 5

MAXIMUM ALLOWABLE CLASS I VARIANCE LIMITS

Pollutant	Maximum allowable increase (micrograms per cubic meter)
Particulate matter:	
Annual geometric mean	10
24-hour maximum	30
Sulfur dioxide:	
Annual arithmetic mean	15
24-hour maximum	91
3-hour maximum	325

SOURCE: The North Dakota State Department of Health Air Pollution Control Regulations 1978.

will not adversely affect air quality related values of the area (including visibility). The Governor, after consideration of the federal land manager's recommendation (if any) and subject to the federal land manager's concurrence, may grant a variance from such maximum allowable increase. If a variance is granted, the Department shall issue a restricted permit to such source provided the applicable requirements of the prevention of significant deterioration regulations are otherwise met. Restrictions on this type of permit to construct would include a requirement that the source comply with such emission limitations as may be necessary: (1) to assure that emissions of sulfur dioxide will not (during any day on which the otherwise applicable maximum allowable increases are exceeded) cause or contribute to concentrations which exceed the maximum allowable increases over the baseline concentrations shown in Table 6; and (2) to assure that the emissions will not cause or contribute to concentrations which exceed the otherwise applicable maximum allowable increases for periods of exposure of 24 hours or less for more than 18 days, not necessarily consecutive, during any annual period.

The third possible variance route is a variance granted by the Governor with the President's concurrence. In any case, where the Governor recommends a variance to which the federal land manager does not concur, the recommendations of the Governor and the federal land manager shall be transmitted to the President. The President may approve the Governor's recommendation if the President finds that such variance is in the national interest. If such a variance is approved, the Department shall issue a restricted permit to construct; provided that the applicable requirements of the prevention of significant deterioration regulations are otherwise met. Restrictions on this type of permit to construct would include a requirement that such source

TABLE 6

MAXIMUM ALLOWABLE SULFUR DIOXIDE VARIANCE INCREASE IN CLASS I AREAS AS A FUNCTION OF LOW AND HIGH TERRAIN AREAS

Maximum allowable sulfur dioxide increase
(micrograms per cubic meter)

Period of exposure	Low Terrain areas[1]	High Terrain areas[2]
24-hour maximum	36	62
3-hour maximum	130	221

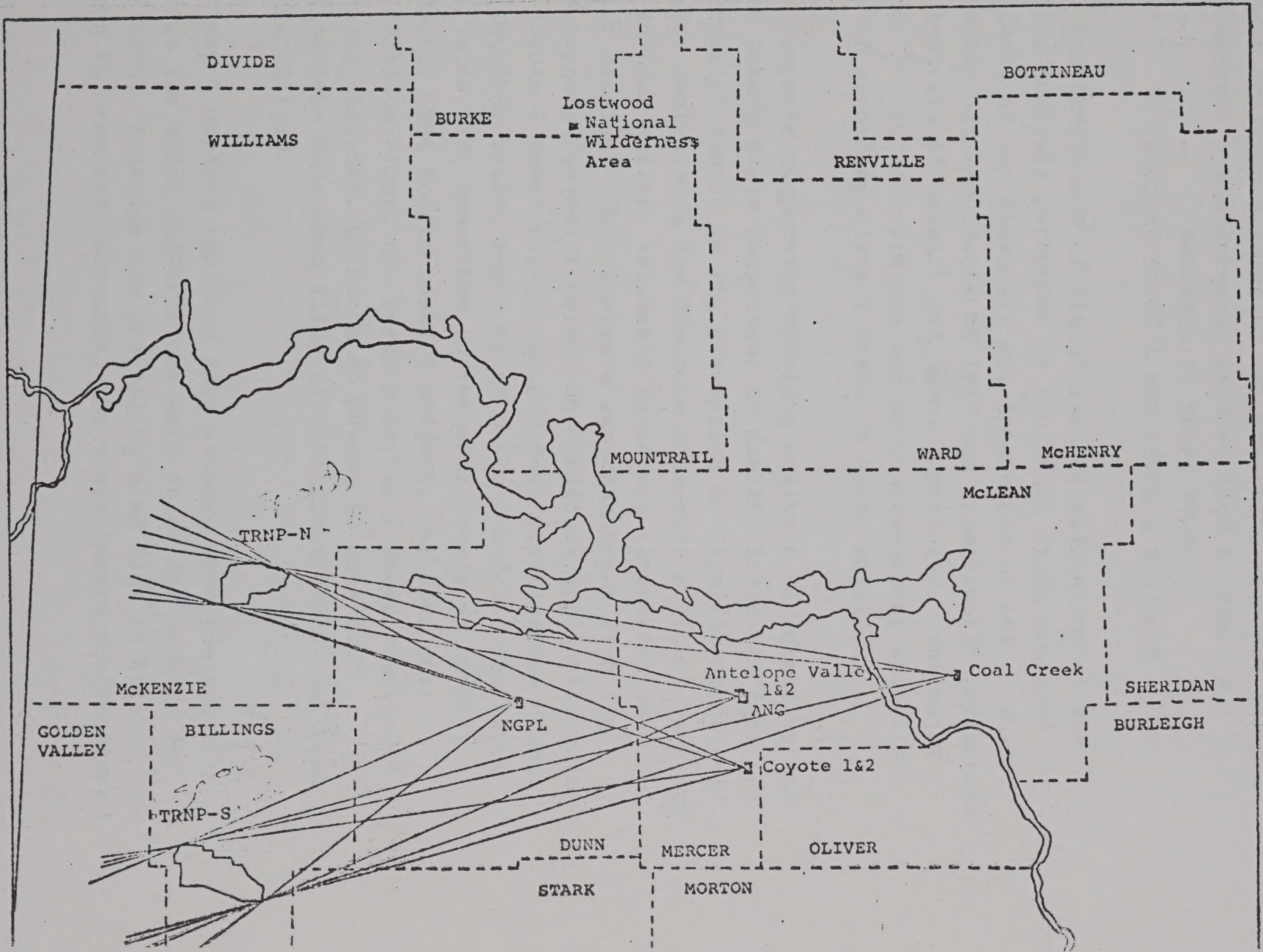
SOURCE: North Dakota State Department of Health Air Pollution Control Regulations 1978.

[1] Low Terrain means any area other than high terrain.

[2] High Terrain means any area having an elevation of 900 feet or more above the base of the stack of a facility.

MAP 1

RELATIONSHIP OF LEVEL 1 AND LEVEL 2 SOURCES TO THE THEODORE ROOSEVELT NATIONAL PARK (TRNP) WITH WIND FLOW VECTORS


DIVIDE
BURKE
BOTTINEAU
WILLIAMS
Lostwood National Wilderness Area
RENVILLE
MOUNTRAIL
WARD
McHENRY
McLEAN
TRNP-N
Coal Creek
Antelope Valley 1&2
ANG
SHERIDAN
McKENZIE
NGPL
BURLEIGH
GOLDEN VALLEY
BILLINGS
Coyote 1&2
TRNP-S
DUNN
MERCER
OLIVER
STARK
MORTON

comply with emission limitations on the permit as may be necessary to satisfy the increments and time periods allowed under a variance granted by the Governor, with the federal land manager's concurrence, as described in Table 6.

ANALYSIS OF DRAFT STUDY
PROPOSED LEVEL 1 AND LEVEL 2 PROJECTS

The Prevention of Significant Deterioration of Air Quality Analysis performed in the Draft Study preceded the enactment of the Clean Air Act Amendments of 1977. The Clean Air Act Amendments of 1977 has dramatically influenced the analysis of Level 1 and Level 2 projects. The major change in the analysis was due to Congressional establishment of mandatory Class I areas in North Dakota.

Computer dispersion modeling analysis performed by the North Dakota State Department of Health, indicated that the controlling factor in the Prevention of Significant Deterioration analysis is the Theodore Roosevelt National Park and the 24-hour maximum allowable increment (increase) for sulfur dioxide. This analysis was concurrent with the Department's review of permit to construct applications for the Coyote 1 Power Plant, the ANG Coal Gasification Plant, and Antelope Valley Power Plant Units 1 and 2. The three facilities were described in the Draft Study as Level 1 projects. The fourth Level 1 project, the NGPL Coal Gasification Plant, the Level 2 Coyote 2 Power Plant were likewise analyzed, although no permit to construct applications have been filed with the Department for these two facilities.

Map 1 depicts the wind flow vectors from the three sources for which applications were filed for permits to construct. Although the prevailing wind flow in North Dakota is from the northwest, the winds toward the Theodore

Roosevelt National Park were determined by the Department to be of sufficient frequency and duration to affect the Class I area maximum allowable increments available in the Park. The Coal Creek Power Plant, which is now completing construction, was included in this analysis since it was issued a permit to construct after January 1, 1975. In North Dakota, the baseline upon which increments are determined is January 1, 1975. The maximum or controlling case is predicted by computer dispersion modeling to occur in the South Unit of the Park.

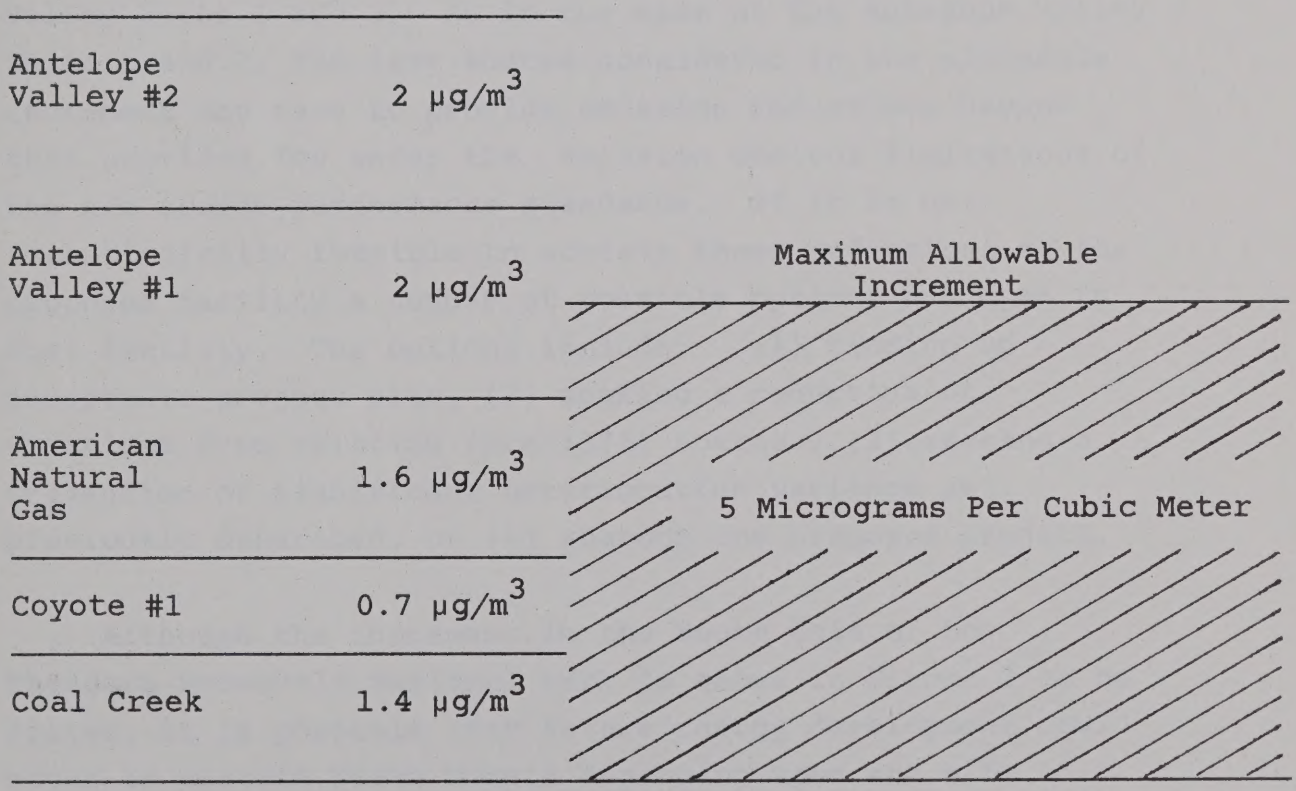
Sulfur Dioxide Emission Reductions

Following an extensive computer analysis, the predicted limiting case for the Level 1 and Level 2 projects was determined to be the 24-hour maximum sulfur dioxide increment or a maximum allowable increase of sulfur dioxide of 5 micrograms per cubic meter. The increment contributed by each source using the design information from the Draft Study is shown in Figure 1.

The computer predicted increment contributed by Antelope Valley Power Plant Units 1 and 2 exceeds the maximum allowable combined increment of 5 micrograms per cubic meter. A permit to construct could not be granted for the Antelope Valley Units 1 and 2 unless the predicted sulfur dioxide increase was reduced from 4 to 1.3 micrograms per cubic meter. In order to accomplish this reduction in sulfur dioxide increment in the Theodore Roosevelt National Park, the sulfur dioxide emissions from Antelope Valley Units 1 and 2 had to be reduced by 67.5% below that which would have been normally permitted under the Clean Air Act Amendments of 1970. The owner of the proposed Antelope Valley Units 1 and 2 agreed to these additional restrictions. Following the completion of the Department's review and respective 30-day public comment periods, permits

FIGURE 1

INFLUENCE OF SULFUR DIOXIDE EMISSION SOURCES
UPON PREVENTION OF SIGNIFICANT DETERIORATION
CLASS I ALLOWABLE INCREMENTS
IN THE THEODORE ROOSEVELT NATIONAL PARK
(24-HOUR SULFUR DIOXIDE LIMITATION)
PRIOR TO CLEAN AIR ACT AMENDMENTS OF 1977



SOURCE: North Dakota State Department of Health using pre-Clean Air Act Amendments of 1977 emission data from the emission sources

NOTE: $\mu g/m^3$ = micrograms per cubic meter

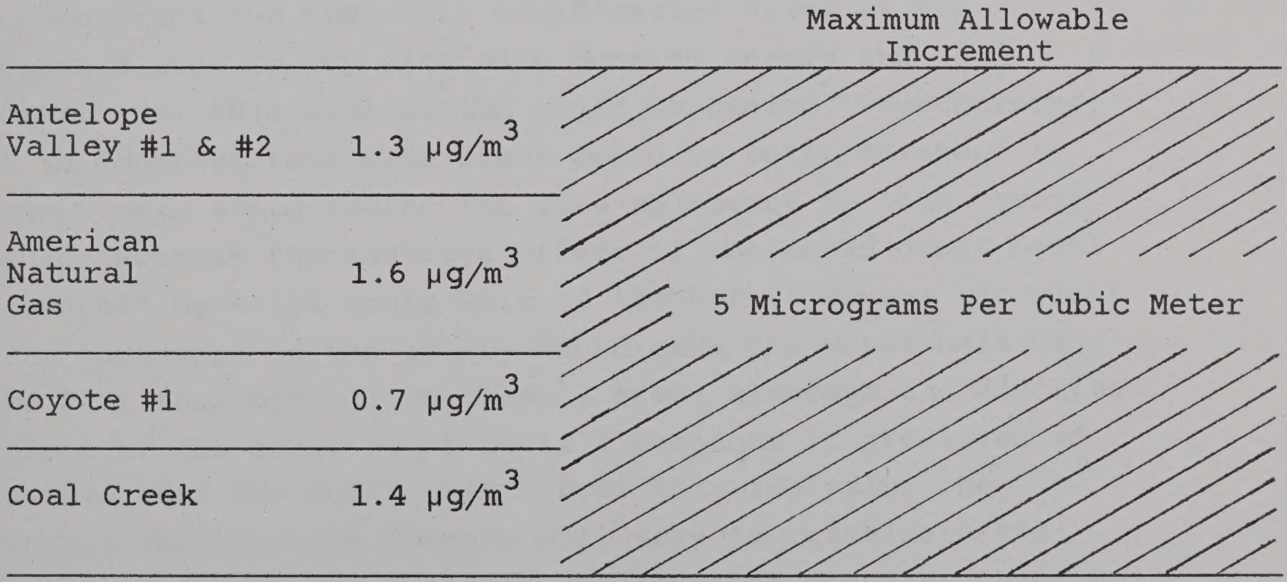
to construct were granted for Coyote 1, ANG Coal Gasification plant and Antelope Valley Units 1 and 2. These permits are conditioned to limit emissions such that the allowable individual contributions to the maximum 5 microgram per cubic meter restriction do not exceed those shown in Figure 2. These three Level 1 sources are now under construction.

The sequence used by the Department in evaluating the increment available for future industrial and energy development is based upon the order in which permit to construct applications are received by the Department and/or permits to construct are issued. This sequence is evident in Figures 1 and 2 with the first source considered in the increment as Coal Creek and the last source the Antleope Valley Units 1 and 2. As in the case of the Antelope Valley Units 1 and 2, the last source considered in the allowable increment may have to provide emission reductions beyond that provided for under the emission control limitations of the new source performance standards. If it is not technologically feasible to achieve these reductions at the proposed facility a number of possible options are open to that facility. The options include: (1) finding an acceptable project site, (2) seeking a reduction of emissions from existing (pre-1975) sources, (3) seeking a Prevention of Significant Deterioration variance as previously described, or (4) abandon the proposed project.

Although the increment in the South Unit of the Theodore Roosevelt National Park is shown in Figure 2 to be filled, it is possible that future energy development could occur in western North Dakota depending upon the site location of that proposed development. Selection of a site such that the additive effect of the sources in Figure 2 is reduced could allow for additional development. The site location of future developments, therefore, becomes a

FIGURE 2

INFLUENCE OF SULFUR DIOXIDE EMISSIONS FROM PERMITTED SOURCES
UPON PREVENTION OF SIGNIFICANT DETERIORATION
CLASS I ALLOWABLE INCREMENTS
IN THE THEODORE ROOSEVELT NATIONAL PARK
(24-HOUR SULFUR DIOXIDE LIMITATION)


Maximum Allowable Increment
5 Micrograms Per Cubic Meter

Antelope Valley #1 & #2	1.3 μg/m^3
American Natural Gas	1.6 μg/m^3
Coyote #1	0.7 μg/m^3
Coal Creek	1.4 μg/m^3

SOURCE: North Dakota State Department of Health 1978

NOTE: μg/m^3 = micrograms per cubic meter

significant factor in the prevention of significant deterioration analysis. A case-by-case review is necessary for each permit to construct application examining the combined effect of the new source and those permitted sources which preceded it.

As referenced earlier, the proposed NGPL Coal Gasification Plant (the fourth Level 1 project), has not applied for a permit to construct. However, a review of that project was conducted similar to the other three Level 1 sources using design data and information supplied by the company for preparation of the Draft Study. The results of the computer dispersion modeling analysis predicted that the individual contributions of the other three Level 1 projects completely consume the maximum allowable 5 microgram per cubic meter increment in the Theodore Roosevelt National Park without an additional predicted 1.6 microgram per cubic meter contribution of sulfur dioxide from the Natural Gas Pipeline Company facility. If an application for a permit to construct the NGPL Coal Gasification Plant at the proposed Dunn County site were pending before the Department, this application would be denied. Furthermore, it is doubtful that this plant could be built anywhere in Dunn County since moving the site southward in this county would increase the additive effect of the three other Level 1 sources upon the South Unit of the Park. Moving the plant site northward in the county could make the North Unit of the Park the controlling Class I area; although the additive effect of the three other Level 1 projects is predicted to be less over the North Unit. From this analysis, the Natural Gas Pipeline Company will have to reevaluate the site location of its proposed gasification plant and have to consider a new site, probably outside of Dunn County and away from the additive effects of the other three Level 1 projects.

Consideration of the Prevention of Significant Deterioration implications as they relate to the major Level 2 project, Coyote 2, results in an analysis similar to that used with respect to the Antelope Valley Units 1 and 2. No application is currently pending for a permit to construct for Coyote 2. As in the case of the Natural Gas Pipeline Company proposed project, no increment is available for a Coyote 2. However, if the sulfur dioxide emissions from Coyote 1 were cut in half, Coyote 2 could then be considered for a permit to construct, such that the combined emissions of sulfur dioxide from Coyote 1 and 2 do not consume more than 0.7 micrograms per cubic meter of the maximum allowable increment in the South Unit of the Theodore Roosevelt National Park.

A comparison of the maximum allowable sulfur dioxide emissions as presented in the Draft Study and that resulting from the Clean Air Act Amendments of 1977 as shown in Table 7. These maximum allowable emissions, expressed in tons of sulfur dioxide per year, were reduced by 64,849 tons per year or a reduction of 56.8% from that which would have otherwise been allowed under the Clean Air Act Amendments of 1970.

The Natural Gas Pipeline Company sulfur dioxide emissions were not included in the total for the column "Under the Clean Air Act Amendments of 1977" since it would not be considered for a permit to construct at its present proposed Dunn County site. If another site is selected outside of Dunn County, but within the seven county study area, the total for Level 1 and Level 2 sources for the column "Under the Clean Air Act Amendments of 1977" would be 60,771 tons per year or a regionwide percent reduction of 53.2% in the sulfur dioxide maximum annual emissions.

TABLE 7

MAXIMUM ALLOWABLE SULFUR DIOXIDE EMISSIONS FROM LEVEL 1 AND LEVEL 2 SOURCES

	Tons of Sulfur Dioxide Per Year	
	Draft Study 1/	Under Clean Air Act Amendments of 1977
Level 1 Sources		
Coyote 1	21,959	21,959
American Natural Gas	12,275	12,275
Antelope Valley	46,713	15,180
Natural Gas Pipeline	11,357	0
Level 1 Subtotal	92,304	49,414
Level 2 Sources		
Coyote 2	21,959	0
Level 2 Subtotal	21,959	0
Total Level 1 and 2	114,263	49,414

1/ Tons per year figures reflect proposed days of operation during the year for the facilities as outlined in the respective permit to construct applications; 7,968 hours (332 days) for American Natural Gas, 8,232 hours (343 days) for Coyote, and 7,896 hours (329 days) for Antelope Valley. In the case of Natural Gas Pipeline, the proposed emission rate is based upon design information supplied for the Draft Study.

These reductions in sulfur dioxide emissions subsequently resulted in reductions in predicted future ground level sulfur dioxide concentrations of the region. The major revisions to the information presented in the Draft Study were with respect to reduction of total sulfur dioxide emissions and predicted air quality effects of the Level 1 and Level 2 projects.

The maximum annual average ground level concentration of sulfur dioxide from all proposed sources occurs in the vicinity of the Antelope Valley and ANG facilities under construction near Beulah in Mercer County. This predicted maximum annual ground level concentration of 2.5 micrograms per cubic meter is approximately one half of the predicted concentration of 5.0 micrograms found in the Bismarck-Mandan vicinity due to existing sources in that area, and due to the existing sources at Center, Stanton, and Coal Creek Station now nearing completion of construction. Although the locations of maximum annual predicted ground level concentrations did not change significantly, the reduction in sulfur dioxide emissions from the Level 1 and Level 2 sources did reduce the magnitude of predicted concentrations across the region. A revised Map 3-2, Projected Annual Concentrations of Sulfur Dioxide from all Existing and Proposed Sources, is found under "Other Changes."

Reduction of sulfur dioxide emissions from Level 1 and Level 2 sources also resulted in reductions to the maximum short-term 24-hour, 3-hour, and 1-hour predicted ground level concentrations. Revised tables, accounting for the emission reductions, are included under "Other Changes." Relating these expected maximum ground level concentrations to effects upon human health, vegetation, and animals are discussed under "Air Pollution Effects." This section

expands and updates the information presented in the climate and air quality impact portion of the Draft Study.

Revised Effects on Air Quality

As previously discussed, the combined maximum allowable annual emission of sulfur dioxide was reduced from 114,263 tons per year to 49,414 tons per year. Although this is a significant reduction in sulfur dioxide emission, the Level 1 and Level 2 projects still would emit a substantial amount of sulfur dioxide into the atmosphere. Examination of revised Map 3-2 shows the maximum projected concentration to occur within 8 miles of Beulah. The projected annual average concentration in this area is shown to range from 1.0 to 2.5 micrograms of sulfur dioxide per cubic meter. These projected annual average concentrations are well within the State standard of 60 micrograms per cubic meter and the Federal standard of 80 micrograms per cubic meter.

With respect to Prevention of Significant Deterioration of Air Quality, the Level 1 and Level 2 projects are located in a Class II area. The maximum allowable annual arithmetic mean increment is 20 micrograms per cubic meter in a Class II area; therefore, only 14% of the allowable annual increment would be consumed by the siting of Coyote 1 and 2, ANG Coal Gasification Plant, and the Antelope Valley Units 1 and 2 in this area. As discussed earlier, these projects would meet the Class I allowable annual increments in the Theodore Roosevelt National Park.

A range of values of 1.0 to 2.5 micrograms per cubic meter is not measurable today, even with the most sophisticated field sampling equipment. The average annual projected concentration is, however, made up of values, highs and lows, the highs of which are measurable and which occur throughout the year. Effects of air pollution may

also occur with higher concentration exposures for shorter averaging periods. These shorter averaging periods (1-hour, 3-hour, and 24-hour) were referred to as short-term sulfur dioxide analysis in the Draft Study.

Table 8 shows a comparative reduction in the worst-case predicted maximum short-term ground level concentrations of sulfur dioxide due to Level 1 and Level 2 projects for atmospheric stability Classes A through F. The concentrations of sulfur dioxide shown in parenthesis are based upon the Draft Study sulfur dioxide emissions. As shown in Table 8, the reduction of sulfur dioxide emissions resulted in a reduction in the amount of increase of sulfur dioxide ambient air concentrations above background.

The maximum sulfur dioxide projected concentrations, which are shown in Table 8, meet the allowable increments in the Class II area and the State and Federal ambient air quality standards. Class A atmospheric stability yielded the greatest increase in projected ground level sulfur dioxide concentrations for the 1-hour, 3-hour, and 24-hour averaging periods. The increased ground level concentrations resulting from the Level 1 and Level 2 projects, when added to the background concentrations, represent the maximum future air quality concentrations expected to occur. Under Class A stability, the future maximum ambient air quality concentrations would be 32% of the state ambient air quality standard for a 1-hour averaging period and 9% of the Federal ambient air quality standard for a 3-hour averaging period. The State standard for a 1-hour averaging period is more restrictive than the Federal 3-hour standard, and therefore, the standard which would prevail in controlling source emissions. The State Ambient Air Quality Standard for a 24-hour averaging period is more stringent than the Federal and is therefore the controlling standard. The Level 1 and

TABLE 8

SHORT-TERM SULFUR DIOXIDE (SO_2) ANALYSIS
LEVEL 1 AND LEVEL 2 PROJECTS

Atmospheric Stability Class	Distance North of ANG/Antelope Valley Site Boundary Wind from South (miles)	Projected Increased Ground Level Concentrations ($\mu g/m^3$)1/			Background Concentrations ($\mu g/m^3$)			Total Projected Concentrations ($\mu g/m^3$)		
		1-hr	3-hr	24-hr	1-hr	3-hr	24-hr	1-hr	3-hr	24-hr
A	Site Boundary	126.1 (331.3)2/	78.5 (206.2)	30.8 (80.9)	105	35	25	231.1 (436.3)	113.5 (241.2)	55.8 (105.9)
B	0.8	63.8 (135.2)	39.7 (84.2)	15.6 (36.7)	105	35	25	168.8 (240.2)	74.7 (119.2)	40.6 (61.7)
C	Site Boundary	117.1 (230.9)	71.4 (140.8)	28.1 (55.4)	105	35	25	222.1 (335.9)	106.4 (175.8)	53.1 (80.4)
C	1.23/	122.6 (241.7)	74.8 (147.5)	29.5 (58.1)	105	35	25	227.6 (346.7)	109.8 (182.5)	54.5 (83.1)
D	8.1	88.9 (153.3)	55.0 (94.7)	21.9 (37.9)	105	35	25	193.9 (258.3)	90.0 (129.7)	46.9 (62.9)
E	36.0	84.2 (120.0)	51.9 (74.0)	20.7 (29.6)	105	35	25	189.2 (225.0)	86.9 (109.0)	45.7 (54.6)
F4/	---	---	---	---	---	---	---	---	---	---
State Ambient Air Quality Standards								715		260
Federal Ambient Air Quality Standards									1300	365
State Class II Prevention of Significant Deterioration Allowable Increment			512	91						

SOURCE: North Dakota State Department of Health 1978

1/ Abbreviation for micrograms per cubic meter.

2/ Numbers in parenthesis ( ) are projected ground level concentrations based upon outdated emissions of SO_2 presented in the Draft Study. These numbers are included for comparison purposes.

3/ These concentrations were estimated to occur with the wind from the north. Therefore, ground level concentrations south of the ANG/Antelope site boundary--thus no contribution from Coyote.

4/ The projected concentrations under F stability class were found to be lower than those concentrations under E stability class for all cases. Also the distances to the point of maximum concentrations are too great such that meteorological conditions are not likely to persist long enough for the plume(s) to travel that far. The stability class is a measure of the ability of the atmosphere to disperse emissions. Generally, Classes A, B, C, and D favor rapid dispersion where as the more stable Classes, E and F, are associated with poor dispersion.

Level 2 projects would be expected to result in a future maximum 24-hour concentration which is 21% of the State Ambient Air Quality Standard.

The Level 1 and Level 2 projects are within the allowable maximum prevention of significant deterioration increments in this Class II area. The maximum expected consumption is 15% of the 3-hour allowable increment and 34% of the 24-hour allowable increment in a Class II. As previously discussed, these projects would meet the allowable annual, 3-hour, and 24-hour increments in the Class I Theodore Roosevelt National Park.

The preceding discussion of projected or expected ambient air quality can be placed into perspective by an analogous situation. In the Stanton vicinity there are two coal-fired electrical generating stations, the Basin Electric Leland Olds Units 1 and 2 and the United Power Association Power Plant. Although the combined generating capacity (828 megawatts) of the Stanton facilities is less than the combined generating capacity of the Antelope and Coyote power plants (1,760 megawatts) near Beulah, the maximum annual combined sulfur dioxide emissions from the Beulah projects (including the ANG Coal Gasification Plant emissions) are approximately 1,500 tons per year less than from the sources in the Stanton area.

Table 9 presents sulfur dioxide sampling data from the rural Stanton air quality monitoring site which is located approximately 6 miles from the two Stanton plants. At the Stanton rural air sampling site 96.6% of the continuous 1-hour sulfur dioxide samples were less than detectable; i.e., in the range of 0 to 26.2 micrograms per cubic meter. One of the difficulties in measuring ambient concentrations of sulfur dioxide at concentrations near the lower detection

TABLE 9

1977 SULFUR DIOXIDE AIR QUALITY DATA
RURAL STANTON SAMPLING SITE

	Maximum Average Concentration Micrograms per Cubic Meter ($\mu g/m^3$)			Percent of Continuous 1-Hour Samples less than 26.2 $\mu g/m^3$ (%)	Percent Data Recovery
Month	1-Hour	3-Hour	24-Hour		
January	131.0	78.6	26.2	95	85
February	78.6	52.4	<26.2	98	96
March	78.6	52.4	<26.2	98	83
April	1/	1/	1/	1/	0
May	1/	1/	1/	1/	0
June	1/	1/	1/	1/	0
July	78.6	78.6	<26.2	89 2/	18 2/
August	52.4	26.2	<26.2	97	100
September	78.6	52.4	<26.2	98	99
October	104.8	78.6	<26.2	95	81
November	52.4	26.2	<26.2	96	93
December	52.4	26.2	<26.2	99	80
Annual Summary	131.0	78.6	26.2	96.6	61.3

Source: North Dakota State Department of Health 1978.

1/ No continuous air sampling data available. The sampling equipment was inoperative. Backup sampling equipment (24-hour bubblers) operating on a frequency of one 24-hour sample every 6 days indicated at maximum 24-hour average concentration of <26.2 $\mu g/m^3$.

2/ Sampling resumed on July 26, 1977.

limit of sampling equipment is in computing an annual average measured concentration.

Computer projections as shown in the revised Draft Study Map 3-2 indicated a projected average sulfur dioxide annual concentration of between 1.0 and 1.5 micrograms per cubic meter in the vicinity of the Stanton air monitoring site south of Stanton. Future sampling with equipment which can measure concentrations of sulfur dioxide below present lower detectable limits (26.2 micrograms per cubic meter) will add to the knowledge of annual arithmetic sulfur dioxide concentrations.

Similar difficulties in measuring these low sulfur dioxide concentrations in the Beulah vicinity can be expected. In any event, the projected concentrations of sulfur dioxide resulting from the emissions of sulfur dioxide from the Level 1 and Level 2 projects will be well within the ambient air quality standards (3 and 4% of annual State and Federal standards, respectively). The significance of these projected air quality impacts is discussed under "Air Pollution Effects."

Analysis of the measured data at the rural Stanton site indicates that the projected sulfur dioxide concentrations resulting from Level 1 and Level 2 sulfur dioxide emissions in the Beulah vicinity are probably conservative; i.e., higher than they should be. However, with respect to future air quality, it is the philosophy of the North Dakota State Department of Health to be cautious. A cautious approach affords protection of air quality, while preventing costly retrofit modifications to the Level 1 and Level 2 projects if the future projected increases in air quality were underestimated.

AIR QUALITY INFLUENCE OF OIL AND GAS PRODUCTION

Concurrent with the writing of the Draft Study, significant oil and gas exploration and production was underway in the western edge and beyond the seven-county study area. Normally, oil and natural gas production would not involve major air quality considerations. However, much of the gas which has been discovered in this area is sour gas containing hydrogen sulfide ranging in concentration from less than 2% to 24%.

Sour gas presents potential air quality problems following development of these wells, and until the gas can be sweetened to pipeline-quality for distribution to consumers as natural gas. To allow some oil production with minimum waste of the state's natural gas, industry has cooperated with the State Industrial Commission in reducing oil production to 100 barrels per day per well until gas sweetening plants can be built to remove hydrogen sulfide from the natural gas.

The reduction of oil production to conserve natural gas has also served to reduce the potential impact upon air quality which would have otherwise occurred. For safety, in the absence of sweetening plants and given the concentration range of hydrogen sulfide, it is necessary to flare the sour gas. Flaring the gas converts the hydrogen sulfide to sulfur dioxide; therefore, any reduction in the amount of sour natural gas flared will reduce the amount of sulfur dioxide in the ambient air.

Oil and Gas Production Potential

The Little Knife Field, which is located along the common boundary of Dunn and Billings Counties, has grown from a discovery well in late 1976 to 68 producing wells in

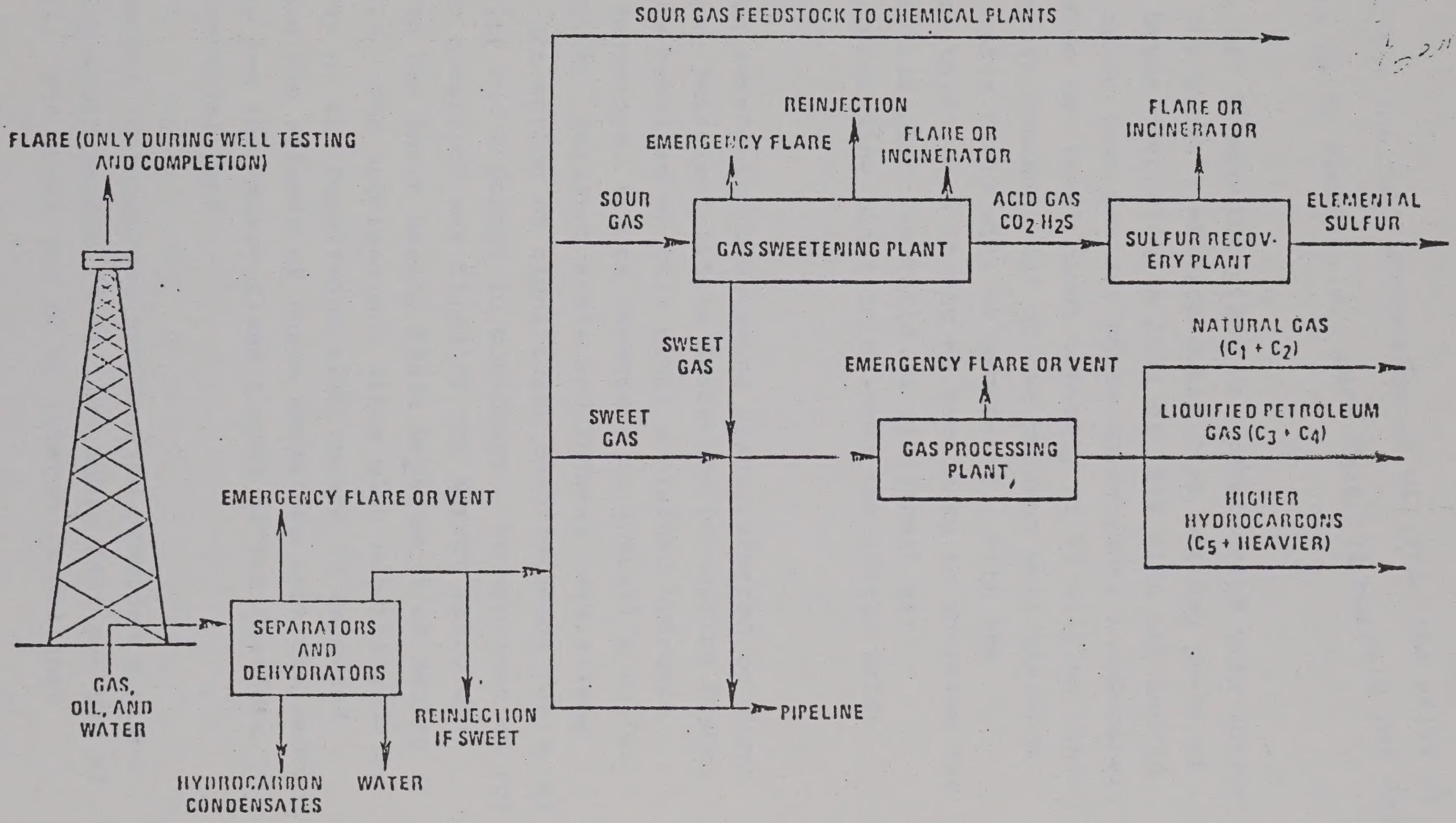
October of 1978. This field is increasing at the rate of about one new production well per week. Only five dry holes have been drilled in this field, to date. It is estimated that the Little Knife Field will eventually contain 120 wells. The wells in this field produce both oil and gas. The gas in this field is primarily sour, although a few sweet gas wells have been drilled. The average hydrogen sulfide concentration in the gas was initially estimated at 12%.

In addition to the Little Knife Field, which is now well established, other potential oil and gas finds occurred in late summer of 1978. These exploration wells could develop into additional fields. Two finds with specific air quality potential problems are oil and sour gas production wells located just north of the Prevention of Significant Deterioration Class I Theodore Roosevelt National Park South Unit and a sour gas well located just north of the Park North Unit. Although the sour gas concentration of hydrogen sulfide (4 to 6%) is lower than that found in the Little Knife Field, the wells are located closer to the Class I Theodore Roosevelt National Park.

Air Pollution Control of Sour Gas

The generalized flow of natural gas and gas products from the well to consumers is shown in Figure 3. If the well gas is sweet, the gas either goes directly to a natural gas pipeline or to a gas processing plant to recover liquefied petroleum gas and higher hydrocarbons. However, if the well gas is sour, as is the case generally in the Little Knife Field, the gas must be sweetened before it can enter the pipeline or gas processing plant. There are no major chemical processing plants in North Dakota so all of the sour gas goes to the gas sweetening plant. The sulfur

FIGURE 3
GENERALIZED FLOW DIAGRAM OF THE NATURAL GAS INDUSTRY


SOUR GAS FEEDSTOCK TO CHEMICAL PLANTS
FLARE (ONLY DURING WELL TESTING AND COMPLETION)
REINJECTION
EMERGENCY FLARE
FLARE OR INCINERATOR
FLARE OR INCINERATOR
SOUR GAS
GAS SWEETENING PLANT
ACID GAS $CO_2 \cdot H_2S$
SULFUR RECOVERY PLANT
ELEMENTAL SULFUR
SWEET GAS
NATURAL GAS $(C_1 + C_2)$
EMERGENCY FLARE OR VENT
LIQUIFIED PETROLEUM GAS $(C_3 + C_4)$
SWEET GAS
GAS PROCESSING PLANT
HIGHER HYDROCARBONS $(C_5 +$ HEAVIER)
EMERGENCY FLARE OR VENT
SEPARATORS AND DEHYDRATORS
GAS, OIL, AND WATER
REINJECTION IF SWEET
PIPELINE
HYDROCARBON CONDENSATES
WATER

SOURCE: North Dakota State Department of Health 1977 - Warren Petroleum Little Knife Gas Processing Plant Permit to Construct Application

in the hydrogen sulfide is removed in the sulfur recovery plant.

To allow for full production of oil from the wells of the Little Knife Field; i.e., more than 100 barrels per day per well, a gas sweetening plant was constructed with sulfur recovery. The first 5 million cubic feet per day phase of this plant began operation in July of 1978 with the second 10 million cubic feet per day phase operational in November of 1978. When the total plant capacity of 15 million cubic feet per day is reached, all of the present well gas from the Little Knife Field will be processed. With the expansion of this field it may be necessary to increase the capacity of this plant or build an additional gas sweetening/processing plant in or near the Little Knife Field.

The gas sweetening/processing plant referred to above is the Warren Petroleum Little Knife Gas Processing Plant. The well gas received by this plant contained hydrogen sulfide. Therefore, it was necessary to install a sulfur recovery plant. Existing state and federal regulations required a prevention of significant deterioration review of this facility and a permit to construct. An application for a permit to construct was filed by the Warren Petroleum Company with the North Dakota State Department of Health in October 1977. The application, along with suporting data, was reviewed by the Department with regard to expected emission and the effects of these emissions upon the ambient air quality and the nearby Class I area of the Theodore Roosevelt National Park.

The permit to construct application provided a plant design which would handle 15 million cubic feet per day of natural gas. The plant was to be located in Billings

County. Ninety-eight percent of the sulfur in the gas was to be removed as elemental sulfur and sold. The remaining sulfur in the form of hydrogen sulfide was to be ignited in a tail gas incinerator and changed to hydrogen and hydrogen sulfide. The primary air pollutant from the plant will be sulfur dioxide. Minor pollutants consist of carbon monoxide, oxides of nitrogen, and particulate.

In view of the Clean Air Act Amendments of 1977, this facility was reviewed for best available control technology. After due consideration was given to the environmental, economic, and energy impacts of the various control units, it was determined that the best available control technology for the Little Knife Gas Processing Plant would be represented by an emission limit that could be achieved with a sulfur recovery unit having a guaranteed efficiency of 98%. This 98% sulfur recovery reduced the emissions of sulfur dioxide from from this plant from a potential 160.74 tons per day to 3.23 tons per day. The potential 160.74 tons per day was based upon the flaring of the acid gas without sulfur recovery. The total annual emissions of sulfur dioxide are 1,179 tons per year. All other pollutant emissions (particulate, carbon monoxide, oxides of nitrogen) from the boilers are less than 5 tons per year each.

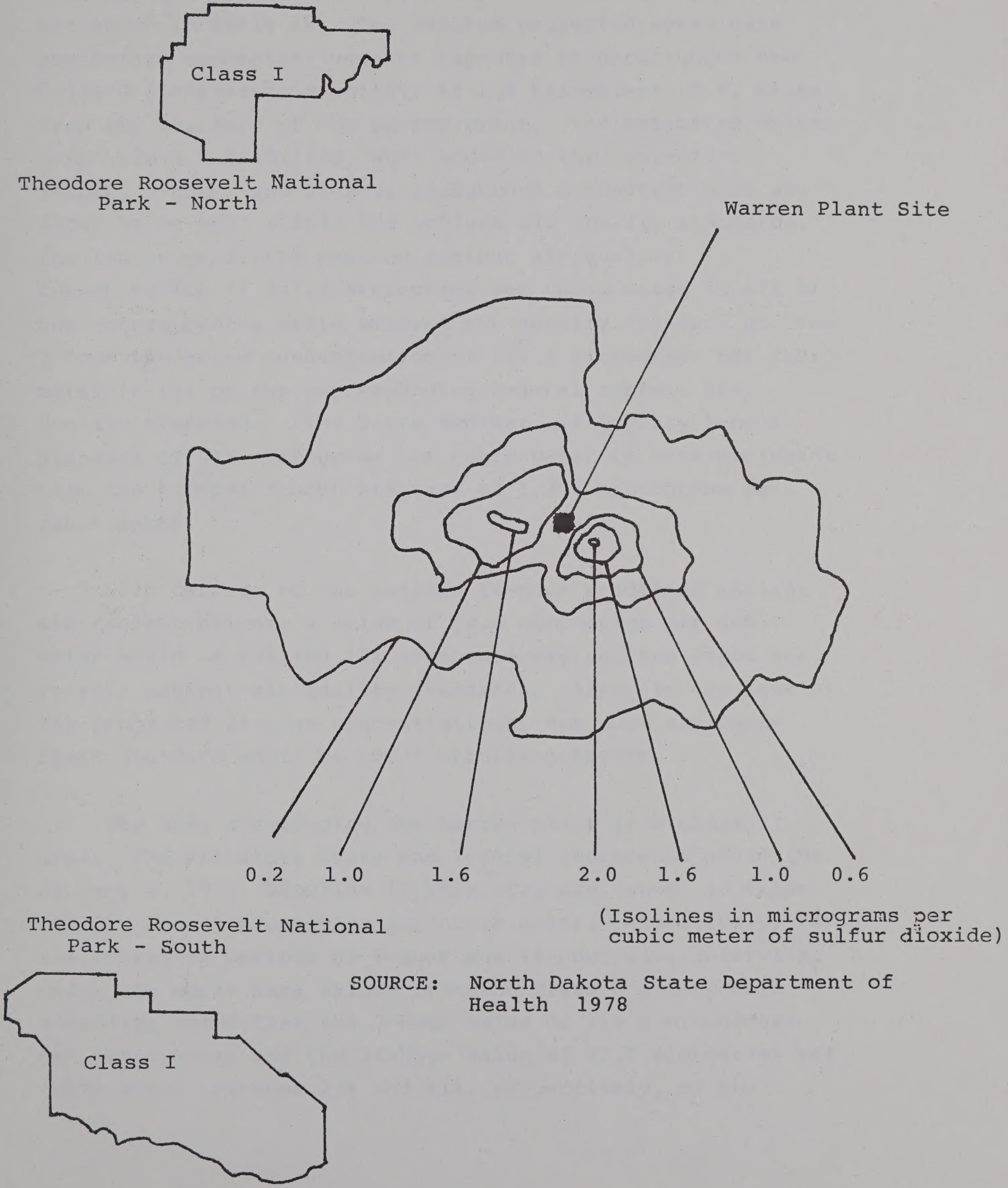
The analysis of the effect upon air quality of the projected emission of 3.23 tons per day from the Warren Petroleum natural gas plant involved a review similar to that of the coal fired Level 1 and Level 2 projects. The emissions from the natural gas plant had to be such that no violations of the Ambient Air Quality Standards or allowable Prevention of Significant Deterioration Class I increments in the Theodore Roosevelt National Park would occur.

The major air pollutant produced by natural gas processing plants receiving sour gas is sulfur dioxide. Therefore, sulfur dioxide was the only air pollutant used in the modeling analysis. However, all air contaminants listed in the ambient air quality standards were examined to insure compliance with the standards and no violations are expected. The estimated ground level concentrations of sulfur dioxide, predicted by the air dispersion modeling, were compared with the Ambient Air Quality Standards and the applicable Prevention of Significant Deterioration increments. Sulfur dioxide was modeled for both annual and short-term (time periods less than or equal to 24 hours) averaging time intervals.

The analysis of annual average ground level concentrations included consideration of the Coal Creek power plant near Underwood, the Coyote Power Plant, the ANG Coal Gasification Plant and the Antelope Valley Power Plant since these permitted stationary sources influence the Theodore Roosevelt National Park sulfur dioxide Prevention of Significant Deterioration increments. Therefore, their combined estimated concentrations were added to Warren Petroleum's projected concentrations. Map 2 shows the projected increase in annual sulfur dioxide ground level concentrations. The maximum predicted concentration increase is 2.7 micrograms per cubic meter. This is 18% of the State annual Prevention of Significant Deterioration Class II allowable increment of 15 micrograms per cubic meter. The estimated value of 2.7 micrograms per cubic meter, when added to an annual sulfur dioxide background level of 5.0 micrograms per cubic meter, gives a value of 7.7 micrograms per cubic meter which is 12.8% of the state annual ambient air quality standard of 60 micrograms per cubic meter.

MAP 2

COMBINED ANNUAL SULFUR DIOXIDE (SO_2) CONCENTRATIONS FROM WARREN PETROLEUM, COAL CREEK STATION, COYOTE STATION, AMERICAN NATURAL GAS AND ANTELOPE VALLEY STATION


Class I
Theodore Roosevelt National Park - North
Warren Plant Site
0.2
1.0
1.6
2.0
1.6
1.0
0.6
(Isolines in micrograms per cubic meter of sulfur dioxide)
Theodore Roosevelt National Park - South
Class I

SOURCE: North Dakota State Department of Health 1978

Results of the short-term sulfur dioxide averaging time intervals, i.e., the 1-hour, 3-hour, and 24-hour periods, are shown in Table 10. The maximum projected worst case short-term concentrations are expected to occur under the Class C atmospheric stability at 1.4 kilometers (0.87 miles) from the boundary of the Warren plant. The estimated values under Class C stability, when added to the respective 1-hour, 3-hour, and 24-hour background concentrations, are shown to be well within the ambient air quality standards. The 1-hour predicted maximum ambient air quality concentration of 337.4 micrograms per cubic meter is 47% of the corresponding State ambient air quality standard and the 3-hour projected concentration of 153.1 micrograms per cubic meter is 12% of the corresponding Federal ambient air quality standard. The State ambient air quality 1-hour standard of 715 micrograms per cubic meter is more stringent than the Federal 3-hour standard of 1,300 micrograms per cubic meter.

With respect to the maximum 24-hour predicted ambient air concentrations, a value of 62.5 micrograms per cubic meter would be 24% and 17%, respectively, of the State and Federal ambient air quality standards. Also, in the case of the projected 24-hour concentrations, the more stringent State standard would be the controlling factor.

The area surrounding the Warren plant is a Class II area. The allowable State and Federal increments above the January 1, 1975, baseline in this area are (shown in Table 10) 512 and 91 micrograms per cubic meter, respectively, for the averaging periods of 3-hour and 24-hour time intervals. Using the worst case values from the Class C atmospheric stability shows that the 3-hour value of 118.1 micrograms per cubic meter and the 24-hour value of 37.5 micrograms per cubic meter consume 23% and 41%, respectively, of the

TABLE 10

WARREN PETROLEUM SHORT-TERM SO_2 ANALYSIS

		Micrograms per Cubic Meter ($\mu g/m^3$) of SO_2								
		Projected Maximum Concentration1/			Background Concentration			Total Concentration		
Stability Class	Distance From Boundary of Warren Plant (km)	1-hour	3-hour	24-hour	1-hour	3-hour	24-hour	1-hour	3-hour	24-hour
A	0.6	79.6 (0%)2/	49.5 (0%)	19.5 (0%)	105	35	25	184.6	84.5	44.5
B	0.9	56.5 (0%)	35.1 (0%)	13.8 (0%)	105	35	25	161.5	70.1	38.8
C	1.4	232.40 (53%)	118.1 (44%)	37.5 (30%)	105	35	25	337.4	153.1	62.5
D	3.2	221.5 (55%)	112.2 (46%)	35.7 (32%)	105	35	25	326.5	147.2	60.7
E	7.6	133.2 (68%)	82.1 (68%)	32.8 (68%)	105	35	25	238.2	117.1	57.8
F	17.4	84.9 (68%)	52.4 (68%)	20.9 (67%)	105	35	25	189.9	87.4	45.9
State Ambient Air Quality Standards								715		260
Federal Ambient Air Quality Standards									1300	365
State and Federal PSD Class II Area Increments			512	91						

Source: North Dakota State Department of Health 1978

1/ Projected maximum concentration includes consideration of other SO_2 emissions including the Coal Creek power plant, the Coyote power plant, the ANG coal gasification plant and the Antelope Valley Power plant as well as the Warren Plant.

2/ Number in parenthesis ( ) indicate the % of the projected maximum concentration due to source emissions other than from the Warren plant.

3-hour and 24-hour increment available in the area surrounding the Warren plant. Under atmospheric stability Classes A and B, the meteorological conditions are such that there was no interaction of emissions of sulfur dioxide from the Warren plant with those from the other sources considered in this analysis. However, under atmospheric stability Classes C through F, a greater influence of long-range transport of sulfur dioxide is seen with the other sources accounting for 30 to 68% of the total maximum increase.

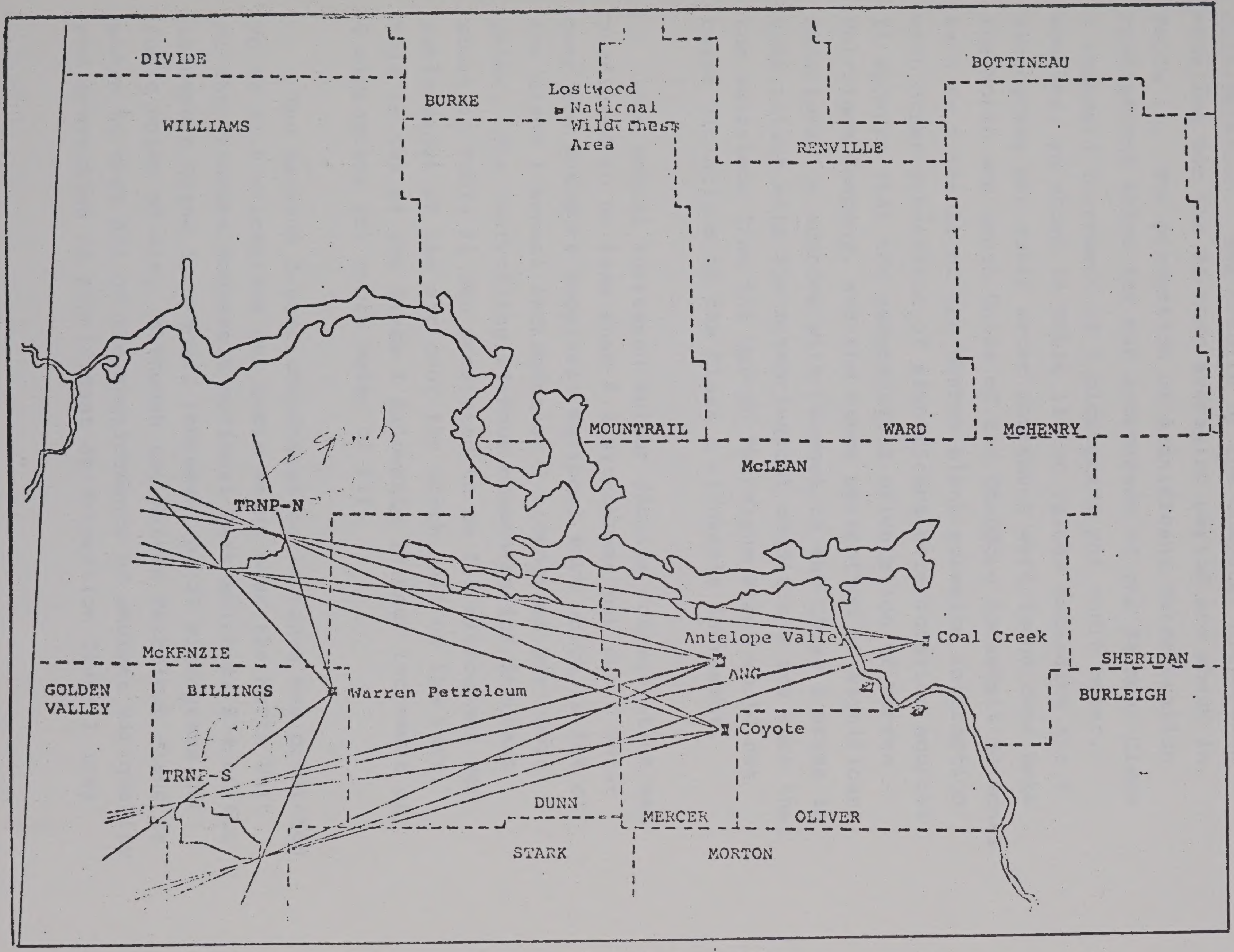
The effect of the Warren plant on the allowable Prevention of Significant Deterioration Class I area increments in the Theodore Roosevelt National Park was also examined. In the previous discussion of the air quality effects of Level 1 and Level 2 projects, the allowable increment of 5 micrograms per cubic meter for the 24-hour sulfur dioxide averaging period was shown to be filled. The 24-hour sulfur dioxide increment in that case was the controlling factor. As will be shown, the Prevention of Significant Deterioration review of new sources must be on a case-by-case basis.

On Map 3, the Warren Plant is shown to be outside of the major wind flow vectors to the Theodore Roosevelt National Park from the distant sources of Coal Creek, Coyote, ANG, and Antelope Valley. Furthermore, the Warren plant is much closer to both the North and South Units of the Park. Contrasted with the analysis of the long-range transport of sulfur dioxide from the four remote facilities, the 3-hour allowable increment will become a more limiting factor.

With the addition of the Warren plant into the prevention of significant deterioration analysis process, the interaction of sulfur dioxide emissions changed by virtue

RELATIONSHIP OF LEVEL 1, LEVEL 2, AND WARREN PETROLEUM SOURCES TO THE THEODORE ROOSEVELT NATIONAL PARK WITH WIND FLOW VECTORS

MAP 3


DIVIDE
BURKE
Lostwood National Wilderness Area
BOTTINEAU
WILLIAMS
RENVILLE
MOUNTRAIL
WARD
McHENRY
McLEAN
TRNP-N
Antelope Valley
Coal Creek
McKENZIE
SHERIDAN
ANG
GOLDEN VALLEY
BILLINGS
Warren Petroleum
BURLEIGH
Coyote
TRNP-S
DUNN
MERCER
OLIVER
STARK
MORTON

SOURCE: North Dakota State Department of Health, 1978.

of the geographic locations of the five sources under consideration. The results of the computer dispersion modeling for the 24-hour averaging period are shown in Table 11. The prevention of significant deterioration regulations allow for one exceedance of the 24-hour Class I standard increment of 5 micrograms per cubic meter. However, as shown in Table 11, no values exceeding the 5 micrograms per cubic meter increment were found over both the North and South Units of the Theodore Roosevelt National Park as a result of the Warren plant emission interaction with other prevention of significant deterioration sources. It appears that the geographical orientation of Warren Petroleum Company, and the other prevention of significant deterioration sources with respect to the Class I areas in combination with the meteorlogical conditions are such that the emissions from the Warren Petroleum Plant would not cause violations of the Class I allowable increment.

The annual increased sulfur dioxide concentration was predicted to be less than 0.2 micrograms per cubic meter over the Theodore Roosevelt National Park which is 10% of the Class I annual increment of 2 micrograms per cubic meter. The controlling 24-hour concentration increase shown in Table 11 was predicted to be 2.5 micrograms per cubic meter of the air over the North Unit of the Park. This is 50% of the Class I allowable 24-hour increment of 5 micrograms per cubic meter of air.

The maximum 3-hour concentration increase was predicted to be 21.8 micrograms per cubic meter over the North Unit of the Theodore Roosevelt National Park which is 87% of the allowable Class I, 3-hour, increment of 25 micrograms per cubic meter of air. Although the Warren Petroleum Plant is shown to meet all of the requirements of ambient air quality and prevention of significant deterioration Class I area

(see Table 11) increments, the 3-hour Class I allowable increment is the most limiting factor in consideration of future expansion of the gas production capacity at this plant site. Following this air quality analysis and a subsequent 30-day public comment period, a Permit to Construct was granted for this facility.

With respect to the oil and gas finds mentioned earlier (which are closer to the Theodore Roosevelt National Park and which represent possible field development), plans are now underway considering the utilization of gas processing plants similar to the Warren Petroleum Plant. The designs for these gas processing plants will be carefully reviewed to assure that the Class I allowable increments for sulfur dioxide in the Park are not exceeded.

Influence on Coal Development

Siting and air pollution control design considerations of future sour gas processing plants and future coal-fired facilities are major factors in the location and extent of possible further increases in energy development in western North Dakota. As has been shown earlier, future coal development potentials east of the Theodore Roosevelt National Park in the seven county study area have already been limited by the emission of sulfur dioxide from the coal-fueled Level 1 and Level 2 projects in the Beulah vicinity. The Antelope Valley and Coyote (Unit 2, if built) power plants have to reduce their sulfur dioxide emission in order to meet Theodore Roosevelt National Park Class I allowable increments. The denial of a Permit to Construct for the NGPL Coal Gasificiation Plant in Dunn County is expected because no Theodore Roosevelt National Park Class I sulfur dioxide 24-hour increment is available for this plant (given proposed emission levels and plant site location).

TABLE 11

THEODORE ROOSEVELT NATIONAL PARK

- ESTIMATED SO_2 GLC's[1/] ($\mu g/m^3$)* -

1964 Day	TRNMP Unit	Total[2/]	Coal Creek	Coyote	Basin 1	Basin 2	ANG	Warren Petroleum
34	North	2.5	0	0	0	0	0	2.5
300	North	4.1	0.7	0.2	0.4	0.4	1.0	1.4
23	South	3.6	0	1.9	0.2	0.2	0.8	0.5
318	South	2.2	0.7	0.5	0	0	0.1	0.9

Source: North Dakota State Department of Health 1978

1/ GLC is the abbreviation for ground level concentration.
2/ Class I 24-hour SO_2 standard increment is 5 $\mu g/m^3$. May be exceeded once only.

* micrograms per cubic meter

Availability of Class I increments in the Theodore Roosevelt National Park for future coal development anywhere in western North Dakota may be limited by oil and gas development since much of the gas is sour and the location of the sour gas wells and possible gas processing plants is nearer the North and South Units of the Park. Furthermore, oil and gas development moves at a more rapid pace. For example, the Warren Petroleum Plant was operational within approximately one year of filing of a Permit to Construct, and capable of processing 15 million cubic feet of natural gas per day. On the other hand, many years of design go into most coal-fueled plants before a Permit to Construct application is filed with the Department.

If gas containing hydrogen sulfide continues to be found in new wells around the Theodore Roosevelt National Park, the allowable increments possibly available for future coal development may be consumed in whole or part before coal-fuel plants are designed and Permit to Construct applications are filed. It would appear that mine-mouth coal utilization in western North Dakota has hit a plateau, at least east of the Park. In any event, careful attention to the site location and design of pollution control devices for major energy development projects in western North Dakota, whether coal or sour natural gas, will be required if energy development is to continue.

Oil and gas production in western North Dakota has unique characteristics which makes the protection of air quality difficult. In addition to the rapid developments which have occurred, air quality analysis of this development is complicated by other factors as well. Review of coal-fueled projects are also involved and complicated. However, before coal development projects are constructed, there is an opportunity to review designs and specifications

and have a resonable expectation of air pollutant emissions and their effects upon air quality.

Contrasted to this pre-design situation, it is not known until the well is completed whether potential air pollution problems exist. When a new well is drilled it is not known if it will be a dry hole or a producer, if it is a producer whether it is oil and/or gas, if it produces gas whether it is sweet or sour gas, and if it is sour what is the concentration of hydrogen sulfide and quantity of gas. Many of the unknowns in the Little Knife Field have been resolved because of the degree of development which has occurred in that field. However, there are a number of unknowns yet to be determined with the drilling of exploration wells in closer proximity to the Theodore Roosevelt National Park.

Air pollution control and prevention of future potential problems have been actively pursued in North Dakota since the 1969 passage of an Air Pollution Law by the State Legislature. Much has been accomplished in 10 years; however, as our knowledge advances, many unresolved environmental issues continue to surface. Some important issues must be examined in more detail in the years ahead: (1) the possibility of carcinogenic and other adverse impacts of man-made materials at low concentration levels over long periods of time; (2) analysis and monitoring of trace quantities of pollutants in the air, water and land environment; (3) synergistic interactions of pollutants in the environment; and (4) long distance atmospheric transport of pollutants. These are examples of issues concerning the relationship of energy development projects to effects upon the environment. These issues are discussed under "Air Pollution Effects."

AIR POLLUTION EFFECTS

In consideration of amendments to the Federal Clean Air Act, Congress received testimony, reports, and studies which raised doubts concerning the adequacy of present National Ambient Air Quality Standards and by association, the State Ambient Air Quality Standards. Questions included: (1) do the present standards really protect public health of all people including the sensitive or susceptible groups within the broader "healthy" population; (2) are standards for more pollutants needed to protect the environment, including cancer causing chemicals, derivative pollutants that change form in the environment (e.g., sulfur dioxide to sulfates), radioactive material and trace metals; and (3) should the standards be tightened in light of air quality effect studies on vegetation showing damage occurring at levels below the federal standards.

It is appropriate to question the adequacy of ambient air quality standards since this is the measure of acceptability or non-acceptability of future proposed actions. The Clean Air Act Amendments of 1977 reemphasize the need for greater attention to the cause-effect relationships of air quality, public health, and welfare. Specific tasks were detailed in this law which require the Administrator of the EPA to implement this reemphasis. These tasks will be addressed under "Air Pollution Effects" relating, where appropriate, the effects which may be expected from Level 1 and Level 2 projects.

Ambient Air Quality Standards

Ambient air quality standards play an important role in evaluating the environmental impacts of proposed future energy development activities. This was the case in the Draft Study. Effects upon air quality were discussed in

Chapter 3 of the Draft Study in terms of whether emissions from proposed Level 1 and Level 2 projects would result in future air quality levels within the ambient air quality standards. The decision role of the ambient air quality standards was again shown in the discussion of mitigation in Chapter 4 of the Draft Study. The role of the ambient air quality standards in both Chapter 3 and Chapter 4 is one of determining the acceptability of the environmental air quality resulting from Level 1 and Level 2 projects, and to determine if additional mitigation measures will be needed to alleviate potential future environmental effects.

In the air quality environmental effects and mitigation portions of the Draft Study, the proposed major air emissions from Level 1 and Level 2 projects were found to be well within the ambient air quality standards even under the maximum or "worst case" conditions of expected emissions and meteorology. Statements following this analysis summarized this finding as, "Based upon current air quality standards, the impacts upon the air quality in the seven county study area as a result of the proposed industrial developments would not be significant." In the interest of conserving paper in a document which already was quite large (even without the technical supplements), it was thought that the specialized reader could refer to the analysis results and evaluate the meaning of such results.

The assessment of the impacts of the proposed Draft Study projects was presented within the scope of the scientific knowledge base of relationships between air pollutants, human health, and the environment. Research in the future may clarify these relationships. In this event, air quality standards may be adjusted accordingly in the public interest, so that hazards to the health, safety, property, and welfare of North Dakota's citizens would not occur. Any

proposed energy development, which presents a hazard to the health, safety, and welfare of the citizens of North Dakota through degradation of the air quality by the emissions of regulated air pollutants will not be allowed.

As described earlier, the State of North Dakota has been conservative and cautious in the adoption of ambient air quality standards by setting maximum allowable air quality standards which are equal to or more stringent than the National Ambient Air Quality Standards. The philosophy of the North Dakota State Department of Health, who promulgated the State Ambient Air Quality Standards in 1970, was that the air quality of this state, which is better than existing National Ambient Air Quality Stndards, must not be allowed to degrade to the National Standards. This philosophy has been supported in recent years with the establishment of prevention of significant deterioration laws and regulations which are designed to protect air quality deterioration in areas now cleaner than the National Ambient Air Quality Standards. A side by side comparison of the State and Federal Ambient Air Quality Standards is shown in Table 12.

The state ambient air quality standards set maximum permissible concentrations for 12 air pollutants compared to six pollutants covered by the federal standards. Five of the 12 state standards relate sulfur with sulfur dioxide, its environmental derivative chemical compounds and hydrogen sulfide. Since particulate matter is the major air pollutant in North Dakota, i.e., approaching ambient quality standards, the state has three standards which address total suspended particulate matter, settled particulate matter, and coefficient of haze. The remaining four pollutants, carbon monoxide, photochemical oxidants, hydrocarbons, and

TABLE 12

STATE AND FEDERAL AMBIENT AIR QUALITY STANDARDS

Air Contaminant	Averaging Period	Maximum Permissible Concentration		
		North Dakota	Federal Primary (Health)	Federal Secondary (Welfare)
1. Total Suspended Particulate (μg/m^3)[1]	Annual Geometric Mean	60	75	60
	24-Hour	150[2]	260	150
2. Settled Particulate-Dustfall (units Tons per Square Mile per Month	3-month (residential)	15	-	-
	3-month (industrial)	40	-	-
3. Coefficient of Haze (Units Coefficient of Haze per 1,000 Linear Feet)	Annual Geometric Mean	0.4	-	-
4. Sulfur Dioxide (μg/m^3)	Annual Average	60	80	-
	24-Hour	260	365	-
	3-Hour	-	-	1300
	1-Hour	715	-	-
5. Reactive Sulfur (mg/100 cm^2/day)[3]	Annual Average	0.25	-	-
	1-month	0.5	-	-
6. Suspended Sulfates (μg/m^3)	Annual Average	4	-	-
	24-hour	12[4]	-	-
7. Sulfuric Acid Mist, Sulfur Trioxide or Combination (μg/m^3)	Annual Average	4	-	-
	24-Hour	12[4]	-	-
	1-Hour	30[4]	-	-
8. Hydrogen Sulfide (μg/m^3)	1/2-Hour	45[5]	-	-
	1/2-Hour	75[6]	-	-
9. Carbon Monoxide (mg/m^3)[7]	8-Hour	10[2]	10	10
	1-Hour	40[2]	40	40
10. Photochemical Oxidants (μg/m^3)[7]	1-Hour	160[2]	160	160
11. Hydrocarbons (μg/m^3)	3-Hour (6-9 a.m.)	160[2]	160	160
12. Nitrogen Dioxide (μg/m^3)	Annual Average	100	100	100
	1-Hour	200[8]	-	-

Sources: North Dakota Air Pollution Control Regulations
Federal Standards - 40 CFR Part 50, 1976

[1] μg/m^3 is the abbreviation for micrograms per cubic meter.
[2] Maximum not to be exceeded more than once per year.
[3] mg/100 cm^2/day is the abbreviation for milligram sulfur trioxide per 100 square centimeters per day.
[4] Maximum not to be exceeded over 1% of the time.
[5] Maximum not to be exceeded more than twice in any five consecutive days.
[6] Maximum not to be exceeded over twice a year.
[7] mg/m^3 is the abbreviation for milligrams per cubic meter.
[8] Maximum not to be exceeded over 1% of the time in any 3-month period.

nitrogen dioxide, are also addressed in the federal standards.

The federal standards are divided into primary and secondary categories. The more stringent of the federal standards are the secondary standards. The secondary standards were designed to prevent effects upon such things as vegetation, animals, and exposed materials. The federal primary standards were designed to protect against adverse health effects. The state philosophy of adopting conservative standards is evident in Table 12.

There is a tendency to treat the ambient air quality standards as a fine dividing line between expected effects and no effects. This is often referred to as a threshold concent. Another premise which holds more scientific validity is that of the linear (no threshold) concept in which effects increase with increased concentration and the only true "no effect" level occurs at zero contamination. One of the most difficult aspects of setting realistic and effective standards is that effects may not be measurable or observable at concentrations above zero contamination. It then becomes a problem of finding the most susceptible element of the environment and setting the air quality maximum concentration and period of exposure to that concentration, such that damage to the susceptible element is not observed. Congress, in recognition of some of the difficulties in setting proper air quality standards and, in view of the questions raised concerning the adequacy of standards, placed a high priority on air quality in the Clean Air Act Amendments of 1977. Congress has asked the Administrator of EPA for reassurance that the standards are adequate and, if reassurance could not be demonstrated, for appropriate action to correct the situation.

The Clean Air Act Amendments of 1977 contained a number of specific provisions related to air quality standards including: (1) changes in wording which broaden the role of the EPA Administrator in setting National Ambient Air Quality Standards; (2) a required determination of the need for a short-term (less than 3-hour) standard for nitrogren dioxide; (3) establishment of a minimum frequency for review of air quality criteria and National Ambient Air Quality Standards; (4) creation of an independent scientific review committee to review the air quality criteria and National Ambient Air Quality Standards; and (5) review of pollutants such as radioactive pollutants, cadmium, arsenic, and polycyclic organic matter which are not currently regulated under the air pollution control regulations.

Various changes in wording in the Clean Air Act Amendments of 1977 have broadened the role of the Administrator of EPA in setting national primary and secondary standards. One example of this is the wording change in Section 108.(A.) of the Clean Air Act Amendments of 1970 which stated that ". . . each air pollutant - (A) which in his judgment has an adverse effect on public health and welfare." The Clean Air Act Amendments of 1977 changed this to read ". . . each air pollutant - (A) emissions of which in his judgment, cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare;." the importance of statements such as this is that a physical demonstration of effects is no longer necessary in making these judgments, but rather a reasonable anticipation of the pollutant to endanger public health and welfare.

Congress requested the Administrator of EPA to revise and reissue criteria relating to concentrations of nitrogen dioxide over such period (not more than three hours) as

deemed appropriate. This criteria is to include a discussion of nitric and nitrous acids, nitrites, nitrates, nitrosamines, and other carcinogenic and potentially carciongenic derivatives of oxides of nitrogen. A number of important air quality questions are evident in this congressional action. These questions relate the need for short-term nitrogen dioxide standards, in addition to the current federal annual standard, to examine cancer causing potential, and to provide a new focus on derivative chemicals. The derivative chemicals are those which change chemical composition; for example, the conversion of nitrogen dioxide to nitrates in the ambient air. This criteria document was to be issued not later than February 7, 1978. The Administrator of EPA was also required to promulgate by August 7, 1978, a national primary air quality standard for nitrogen dioxide (for averaging periods of not more than 3 hours), unless he finds that there is no significant evidence that such a standard is necessary to protect public health. The criteria document and the Administrator's decision as to necessity for this standard had not been published as of October 1, 1978.

The Clean Air Act Amendments of 1977 established the minimum frequency for review of air quality criteria and National Ambient Air Quality Standards changing the frequency from "time-to-time" to "not later than December 31, 1980, at 5-year intervals thereafter." The Administrator could review and revise the criteria or promulgate new standards earlier or more frequently than the required 5-year interval.

An independent scientific review committee was created by the Clean Air Act Amendments of 1977. This committee, appointed by the Administrator of EPA, is to be composed of seven members including at least one member of the National

Academy of Sciences, one physician, and one person representing state air pollution control agencies.

Not later than January 1, 1978, and at 5-year intervals thereafter, the committee must complete a review of air quality and the National Primary and Secondary Ambient Air Quality Standards and recommend to the Administrator any new National Ambient Air Quality Standards and revisions of existing criteria and standards as may be appropriate. This committee must also advise the Administrator of areas in which additional knowledge is required to appraise the adequacy and basis of existing, new, or revised National Ambient Air Quality Standards; describe the research efforts necessary to provide the required information; advise the Administrator on the relative contribution to air pollution concentrations of natural as well as anthropogenic activity; and advise the Administrator of any adverse public health, welfare, social, economic, or energy effects which may result from various strategies for attainment and maintenance of such National Ambient Air Quality Standards.

In consideration of amendments to the Federal Clean Air Act, questions were raised concerning pollutants which were not currently addressed under air pollution regulations. Congress responded to these questions by requesting the Administrator of EPA to review all relevent information and determine whether or not emissions of radioactive pollutants, cadmium, arsenic, and polycyclic organic matter into the ambient air will cause, or contribute to air pollution which may reasonably be anticipated to endanger public health. If the Administrator finds that any of these substances need air pollution regulation, he is to, simultaneously with this determination, include this substance either under a list for air quality criteria and National Ambient Air Quality Standards or National Emissions Standards for

Hazardous Air Pollutants. The determination by the Administrator concerning cadmium, arsenic, and polycyclic organic matter was to be completed by August 7, 1978; however, this was not completed as of October 1, 1978. The determination, with respect to radioactive pollutants, is due by August 7, 1979.

The Administrator, in this section of the Clean Air Act Amendments of 1977, was also to conduct a study, in conjunction with other appropriate agencies, concerning the effect on the public health and welfare of sulfates, radioactive pollutants, cadmium, arsenic, and polycyclic organic matter which are present or may reasonably be anticipated to occur in the ambient air. This study is to include a thorough investigation of how sulfates are formed and how to protect public health and welfare from the injurious effects, if any, of sulfates, cadmium, arsenic, and polycyclic organic matter.

All of the preceding are examples of the importance which Congress placed upon ambient air quality and the need to have standards which will protect public health and welfare. The setting of appropriate standards is not a simple matter. It requires careful scientific analysis. Some of the complexities involved in this analysis will be pointed out in the following discussion.

Comparisons of air quality impacts of Level 1 and Level 2 projects with the Ambient Air Quality Standards are presented in Table 13. The major air pollutant emissions from Level 1 and Level 2 projects are particulate matter, sulfur dioxide, and oxides of nitrogen. The increases in concentration and resulting expected maximum ambient air quality values are compared to the ambient air quality standards. It should be noted that these maximums occur at

TABLE 13

SUMMARY OF PROJECTED AMBIENT AIR QUALITY CHANGES DUE TO LEVEL 1 AND LEVEL 2 PROJECTS

Air Pollutant and Concentration Averaging Period	Ambient Air Concentrations Micrograms per Cubic Meter ($\mu g/m^3$) (1) Projected Maximum Increase Due to Level 1 and Level 2 Projects[1]	(2) Estimated Existing Background[8]	(3) Expected Maximum Air Quality (1) & (2)	(4) Ambient Air Quality Standard
Total Suspended Particulates				
Maximum annual mean[2]	3.0	25.0	28.0	60
24-hour maximum[3]	7.0	80.0	87.0	150
Sulfur Dioxide (SO_2)				
Maximum annual mean[4]	2.5	5	7.5	60(80)[10]
24-hour maximum	30.8	25	55.8	260(365)
3-hour maximum[5]	78.5	35	113.5	(1300)
1-hour maximum	126.1	105	231.1	715
Nitrogen Dioxide (NO_2)				
Maximum annual mean[8]	5.8	5	10.8	100
1-hour maximum[7]	203.1	55	258.1[9]	200[11]

Source: North Dakota State Department of Health 1978

[1] Maximums noted are expected to occur at plant boundaries or within 2 miles of the Level 1 and 2 projects located in the Beulah vicinity.

[2] Geometric mean.

[3] Maximum concentration not to be exceeded more than once per year.

[4] Arithmetic mean.

[5] Averaging period for Federal secondary standard. Ambient air quality standard is not to be exceeded more than once per year.

[6] Arithmetic mean.

[7] Maximum concentration not to be exceeded over 1% of the time in any 3-month period.

[8] Estimated existing background concentrations were derived from North Dakota State Department of Health air quality monitoring stations are representative of existing air quality in the seven-county study area.

[9] This concentration is expected to occur not more than 0.001% of the time on an annual basis and therefore within the averaging periods described in footnote 7 above.

[10] Numbers in parenthesis are the Federal Standards. These are presented in those instances where the State ambient air quality standard is more stringent.

[11] There is currently no Federal standard for NO_2 other than for the annual mean averaging period. This matter is currently under study by the U.S. Environmental Protection Agency for possible promulgation of a short-term (less than 3-hour) standard.

the facility boundaries or within eight miles of the Level 1 and Level 2 project sites in the Beulah vicinity.

The greatest air quality impact of Level 1 and Level 2 projects on air quality will be in Mercer and Oliver Counties. The following discussion will relate the expected air pollution effects of Level 1 and Level 2 project emissions to this maximum impact area, and specifically the Beulah vicinity. An analysis of the maximum effect conditions and the acceptability of Level 1 and Level 2 projects, in that area, would indicate expected effects at a lower level in the rest of the seven county study area, the Fort Berthold Indian Reservation, and the Knife River Indian Villages National Historic Site near Stanton.

Human Health Effects

Contamination of the environment with air pollutants influences the health of persons living within the environment. Clearly, this has been demonstrated in historical urban air pollution episodes which have been attributed to cause-increased hospital admissions, serious illnesses, and deaths. Conversely, as the ambient air quality in major urban areas of the United States has improved, the seriousness and frequency of respiratory diseases related to pollution has reduced. Attaining the National Ambient Air Quality Standards has resulted in decreases in the incidence of emphysema, asthma attacks, and other respiratory diseases.

How much contamination of the environment with air pollutants can be allowed and still protect public health (the susceptible and chronically ill, as well as healthy people) is a major question related to the establishment of ambient air quality standards. The current ambient air quality standards, established in the early 1970s, were

promulgated based upon the scientific evidence available at that time and with the presumption that the standards provided a factor of safety. The National Ambient Air Quality Standards provide standards for six criteria pollutants, and North Dakota Standards, promulgated at about the same time, increased the list of pollutants covered. Further, with respect to sulfur dioxide and nitrogen dioxide, North Dakota set standards which are more restrictive than the national standards, as shown in Table 12.

Testimony in consideration of the Clean Air Act Amendment of 1977 questioned the existence of the factor of safety with reports that the public health is being harmed to some extent, perhaps seriously, at pollutant concentrations less than the national standards. Other questions were raised concerning the limiting of the National Ambient Air Quality Standards to the six criteria pollutants since other pollutants have the potential for health effects.

The factor of safety in preventing health effects has been questioned in terms of indications that deaths have occurred at pollution levels not far above the Federal primary 24-hour standard for sulfur dioxide (365 micrograms per cubic meter). The comparable state ambient air quality sulfur dioxide standard is 260 micrograms per cubic meter which gives greater protection of public health than the current national standards. The projected maximum increase of 30.8 micrograms per cubic meter (Table 13) of sulfur dioxide (24-hour averaging period) resulting from Level 1 and Level 2 projects is expected to result in a maximum ambient air concentration of 55.8 micrograms per cubic meter.

Furthermore, the application of prevention of significant deterioration increments for a Class II area in North

Dakota has the effect of establishing an upper limit (below the ambient air quality standard) on the amount of pollution which will be permitted. In the case of sulfur dioxide, which is one of two pollutants regulated under prevention of significant deterioration regulations (particulate matter is the other), the maximum North Dakota allowable increment for a 24-hour averaging period is 91 micrograms per cubic meter. This 91 micrograms per cubic meter maximum increase of sulfur dioxide effectively sets the expected maximum air quality concentration at 116 micrograms per cubic meter including the estimated existing maximum concentration. The 91 micrograms per cubic meter increment allows for some additional future local development beyond the Level 1 and Level 2 Beulah projects; however, the 116 micrograms per cubic meter ambient air quality concentration level is now the limit on major industrial growth in that area.

Another factor which may further limit the amount of major industrial contamination of air in Mercer and Oliver Counties is the federal designation of the Theodore Roosevelt National Park and the Lostwood National Wilderness Area as Class I prevention of significant deterioration areas. The emissions of sulfur dioxide from the major sources in Mercer County and other applicable interacting sources cannot exceed the allowable Class I area increments. As discussed previously, the allowable increments in the Theodore Roosevelt National Park have been filled with the three Level 1 and Level 2 projects located near Beulah.

The questions of the public health factor of safety in the national primary standards, although important to resolve, do not appear to be urgent with respect to Level 1 and Level 2 projects since prevention of significant deterioration Class I and Class II regulations are providing a factor of safety for the air quality of the seven county

study area. The current expected sulfur dioxide maximum 24-hour ambient air quality concentration of 55.8 micrograms per cubic meter would be considerably better than both the respective state and federal standards of 260 and 386 micrograms per cubic meter.

Similarly, the other current federal air quality standards have been questioned as to the factor of safety they afford in protecting the health of vulnerable groups including infants, the very old, persons with heart and lung disease, and those who are pregnant. These groups could require a better ambient air quality than now provided by the National Ambient Air Quality Standards.

The short-term, i.e., other than annual, maximum concentrations shown in Table 13 do not take into account such factors as frequency of occurrence. Further, these maximums should not be construed as those which would occur throughout the seven county study area. Experience in sulfur dioxide air monitoring by the State Department of Health, near the existing Stanton power plants (which have a somewhat greater sulfur dioxide emission rate than that proposed for the Beulah Level 1 and Level 2 projects), illustrates this point. It was shown in Table 9 of this supplement that 96.6% of the continuous 1-hour sampling for sulfur dioxide near Stanton indicated less than detectable concentrations of sulfur dioxide, i.e., less than 26.2 micrograms per cubic meter.

In North Dakota, the existing air quality is much better than that provided for currently under the National Ambient Air Quality Standards. Therefore, the addition of the six criteria pollutants to the ambient air from Level 1 and Level 2 projects should not result in a perceptible increase in health damage to individuals in Mercer and

Oliver Counties and in the broader seven county study area as a result of these pollutants.

Perceptible health effects, human or animal, are a function of the kind of pollutant, its concentration, frequency and/or duration of this concentration, and the state of health of the pollutant receptor. The current standards have been derived from epidemiological investigations and extrapolation of animal effects in controlled experiments to man. Both routes of effects analysis are useful in the episodic sense with high pollution concentrations, for short exposures, or at a high frequency of elevated concentrations. However, examination of the amount of risk to the public health from exposure to low pollutant concentrations with a relatively low frequency of occurrence is a problem for which no answers presently exist. Various attempts have been made to estimate public health risk from low concentrations of pollutants; however, the results of these studies have, to date, been inconclusive.

In view of the inclusiveness of these studies of low level pollutant exposure, the State Department of Health has considered the setting of ambient air quality standards and the granting of new source permits to construct, on the premise that a "no effects" level of pollution does not exist, and prudent management of air quality is indicated for protection of public health and prevention of future health effects. This philosophy embodies the principle that for every pollutant there is some effect. Whether effects will be perceptible at relatively low concentrations of pollutants, remains to be resolved by more concentrated scientific study and evaluation. A similar approach was taken by Congress in consideration of the Clean Air Act Amendments of 1977, as discussed under "Ambient Air Quality Standards."

Concerns over cancer and other chronic illnesses were expressed in testimony before Congress in consideration of the Clean Air Act Amendments of 1977. No new revelations were presented in this testimony which would directly aid in the standards setting process. It did emphsize, however, that attention must be paid to the potential for increases in cancer and other chronic illnesses as a result of pollutants in the atmosphere. Suggested as possible cancer inducing agents were the pollutants arsenic, cadmium, polycyclic organic matter, sulfur dioxide, sulfates, nitrates, n-nitrosamines, nitrites, and radioactive materials. One problem in defining the role of air pollutants in chronic (low concentration-long exposure) illnesses is that the onset of these diseases takes many years. Another significant problem in defining this role is that cancer and other chronic illnesses have been related to many other causes.

Some problems involved in analysis of chronic illness were exhibited by William Weiss, M.D., in a paper entitled "Lung Cancer Mortality and Urban Air Pollution" (American Journal of Public Health, August 1978, Vol. 68, No. 8). Although information presented in this was "consistent with the hypothesis that air pollution is a factor in the causation of lung cancer, interpretation of a cause-and-effect relationship is unjustified because other important factors have not been taken into account. Smoking and occupational disease are the most significant of these." The assessment of risk in an urban setting from an epdemiological standpoint is desirable in some respects, most notably when there is a statistically sufficient population base to evaluate effects. However, the problems of dealing with pollution cause-and-effect relationships, regardless of urban or rural environment, are many-fold.

Mortality studies involving death rates and cause of death are important and must be performed. These studies, although difficult, are easier than mordibity studies, which examine illnesses less serious than death but certainly which affect the well-being of a person. The mordibity studies also must be performed.

There are many environmental factors which can be related to chronic diseases such as cancer. These environmental factors include substances in food, air, and water, and a person's habitats or lifestyle. Much of the attention to chronic diseases has been from the standpoint of setting standards of quality for these factors to reduce, if not eliminate, the risks to public health linked to these factors.

A sophisticated risk analysis was and still is beyond the scope of the Draft Study. The studies which have been performed, thus far, do not relate to the quality of life which is generally found throughout the seven county study area. Another aspect which makes this analysis difficult and perhaps very judgmental is determining which pollutant has the greatest risk to public health. This is one of the pitfalls in much of the epidemiological work which has been performed thus far.

In "field" environmental studies, as contrasted with closely controlled laboratory experiments, the selection of pollutants measured against effects in the environment is critical to the evaluation of cause-and-effect relationships. If, for example, sulfur dioxide and particulate sulfate data are available in an area and this data is compared with disease in appropriate affected and control populations showing an apparent health effect, there are uncertainties in equating the concentrations of sulfur and

sulfates to these health results. Although sulfur dioxide and sulfates may be linked to the health effect noted in the study, another pollutant, for example arsenic, may be the cause of the health effect; but since there was no measurement of arsenic, the cause-effect relationship is attributed only to sulfur dioxide and its derivative, sulfate. Environmental field studies must be carefully designed and executed to establish a valid cause-effect relationship.

The cause of a given disease may be due to a single identified pollutant, or possibly a group of pollutants, in a synergistic effect. Synergistic effects are due to the action of several pollutants, such that their combined effort is greater than the sum of their individual effects. Synergistic effects are possible; however, even less scientific information is available on this project.

Currently, North Dakota is a relatively healthy place to live. This relationship is shown in Tables 14 and 15, and environment no doubt plays an important role in this relationship. One general indication of well-being of the population is a comparison of average life expectancy at birth for various demographic sub-groups or geographic areas. A comparison of life expectancies for the United States, North Dakota, and the seven county study area is presented in Table 14. Average life expectancy at birth for the State of North Dakota and for five of the seven counties equals or exceeds the national norm. The lowest life expectancy (69.54 years in Morton County) exceeds the comparable figure in nine states and the District of Columbia.

Another comparison includes overall and cause-specific death rates. However, direct comparisons may often be

TABLE 14

AVERAGE LIFE EXPECTANCY AT BIRTH
NORTH DAKOTA, UNITED STATES, AND IMPACT COUNTIES
TOTAL POPULATION
1969 - 1971

Area	Average Life Expectancy At Birth (in years)
United States	70.75
North Dakota	72.79
Burleigh County	72.59
Dunn County	70.75
McLean County	71.88
Mercer County	71.46
Morton County	69.54
Oliver County	69.75
Stark County	71.68

SOURCES:

1. United States and North Dakota -- "North Dakota State Life Tables," Vol. II, No. 35, DHEW Publication No. (HRA) 75-1151, National Center for Health Statistics, HRA, PHS, DHEW, June 1975.

2. Impact Counties -- "Abridged Life Tables for North Dakota Counties, 1970," unpublished manuscript, James P. Beneteau, 596 Demography, University of North Dakota, undated.

misleading due to differentials in the age distribution of the areas under study. To ameliorate this problem, such rates are often age-adjusted (i.e., rates are adjusted to approximate their true values assuming the age distribution of the areas under study are equal). In short, age is controlled in analyzing the direct comparison of age-adjusted death rates for all causes and selected leading causes for the United States, North Dakota, the seven county study area, and selected groupings of counties.

As shown in Table 15, all areas under study exhibit an age-adjusted death rate below that of the United States as a whole. The rate for the seven county area is significantly below that for the United States. All but two of the areas (Stark-Dunn and Mercer-Oliver-McLean) exhibit heart disease death rates below the national norm. All areas exhibit age-adjusted rates below national levels for deaths from malignant neoplasms and from cerebrovascular diseases. The rates for Stark-Dunn and Mercer-Oliver-McLean for malignant neoplasm and cerebrovascular disease are based on a limited number of deaths. However, the total number of deaths observed for the above-mentioned causes for these areas are consistent with long-term trends for the counties.

Since public health risks cannot be directly assigned to changes in air quality resulting from Level 1 and Level 2 projects, public health risks can be placed in better perspective by examination of the existing environment. The existing air quality is a function of natural and man-generated pollutants present in this seven county study area. The existing air quality influences public health.

All of the air pollutants mentioned in consideration of the Clean Air Act Amendments of 1977 are found in the study area, with the exception of polycyclic organic matter which

TABLE 15

DEATHS AND AGE ADJUSTED DEATH RATES ALL CAUSES AND LEADING CAUSES NORTH DAKOTA, UNITED STATES, AND SELECTED IMPACT AREAS

Area	All Causes		Heart Disease		Malignant Neoplasms		Cerebrovascular Disease	
	Deaths	Rate	Deaths	Rate	Deaths	Rate	Deaths	Rate
United States	1,892,438	844.93	716,065	320.66	365,768	165.43	194,016	86.81
North Dakota	5,482	785.75	2,162	305.86	925	131.85	589	81.77
7 County Impact Area	842	744.12	355	314.35	147	131.13	82	71.80
Burleigh - Morton	454	712.83	165	263.03	65	151.23	51	80.45
Stark - Dunn	199	814.12	89	362.60	30	124.37*	21	85.07*
Mercer - Oliver - McLean	189	756.76	101	394.32	22	88.55*	10	38.14*

* Based on less than 30 observations

SOURCES:

Population -

1. Unpublished estimates of county populations, prepared by Bureau of Census for NCI, 1978.
2. "General Population Characteristics," PC(1)-B1-US Summary, 1970 Census of Population, US Bureau of Census, US Department of Commerce, January 1972.
3. "Estimates of the Population of the United States, by Age, Sex, and Race: July 1, 1974 to 1976," Population Estimates and Projection, Series P-25, No. 643, US Bureau of the Census, US Department of Commerce, January 1977.

Vital Statistics -

1. Unpublished tabulations for calendar year 1975, Office of Statistical Services, North Dakota State Department of Health.
2. "Advance Report - Final Mortality Statistics, 1975," Monthly Vital Statistics Reports, Publication No. (HRA) 77-1120, Vol. 25, No. 11, Supplement, National Center for Health Statistics, HRA, PHS, DHEW, February 11, 1977.

has not been reviewed. With the exception of sulfur dioxide and nitrogen dioxide, all of the pollutants are naturally occurring, including radioactive material. Environmental radiation impacts, of Level 1 and Level 2 projects, are discussed under "Radiation Impacts."

Referring to Table 13, the maximum expected sulfur dioxide and nitrogen dioxide ambient air concentrations, combined with a projected low frequency of occurrence, will result in a low risk to public health, with the greatest health risk occurring in Mercer and Oliver Counties. Comparing life expectancy by county in Table 14 and cause of death in Table 15 shows a similar pattern. From this comparison, it appears that the existing power plants located in Center and Stanton have had no perceptible effect upon public health in these counties when compared to the other four counties of this region.

There are presently no ambient air quality standards for arsenic, cadmium, and other trace metals; however, concern has been expressed in testimony before Congress that the emissions of these metals has a potential for chronic health effects, including cancer. In the absence of a standard of comparison, public risks from emission of arsenic and cadmium will be examined in a simplified fashion to relate these emissions to an expected increase of these pollutants in the ambient air.

The coal to be used by Level 1 and Level 2 projects contains arsenic and cadmium. Table 16 presents the average concentration of 14 trace elements and sulfur for lignite from four mines in this region. As seen in Table 16, these concentrations vary from mine-to-mine, and further, the concentrations vary with the samples collected at the individual mines. For purposes of a "worst-case" analysis,

TABLE 16

AVERAGE TRACE ELEMENT CONCENTRATIONS OF FOUR LIGNITE COAL MINES IN CENTRAL NORTH DAKOTA

Element[1]	Coal Mine C-I	C-II	C-III	C-IV	Arithmetic Mean
Arsenic	2.2	1.60	0.96	3.5	2.07
Beryllium	0.9	1.06	0.17	0.86	0.75
Cadmium	0.13	0.12	0.16	0.11	0.13
Chromium	2.10	1.28	0.49	1.3	1.29
Copper	3.42	3.77	1.63	2.7	2.88
Fluoride	11.8	21.0	12.33	17.0	15.53
Lead	0.16	0.18	0.18	0.51	0.26
Mercury	0.02	< 0.02	< 0.02	0.09	[3]
Molybdenum	1.46	1.63	1.53	1.9	1.63
Nickel	0.33	2.40	.065	0.35	0.93
Selenium	0.29	0.49	0.18	0.22	0.30
Uranium	0.59	0.33	0.30	0.65	0.47
Vanadium	3.33	3.73	1.91	1.8	2.69
Zinc	1.41	2.37	1.17	5.3	2.56
Sulfur[2]	0.62	0.72	0.60	0.95	0.72

Source: North Dakota State Department of Health - Trace Element Effects of Energy Conversion Facilities - November 1977.

[1] Concentration in micrograms per gram.
[2] Concentration percent by weight.
[3] Greater than 30% of samples less than detectable limit, resulting in arithmetic mean of <0.02. Sulfur is not a trace element; however, it was included as part of the analysis.

the arsenic concentration of 3.5 micrograms per gram from Mine C-IV and the cadmium concentration of 0.16 micrograms per gram from Mine C-III will be used.

As shown in Maps 3-1 and 3-4 of the Draft Study, the maximum annual average predicted concentration of suspended particulate increase in the ambient air in the seven county study area is approximately one microgram per cubic meter from the Level 1 and Level 2 projects in the Beulah area, exclusive of the mines associated with these projects. The total annual emission of particulate matter from Level 1 and Level 2 sources is 7,075 tons per year (from Tables 3-1 and 3-20 of the Draft Study). This annual particulate emission rate is an average rate of 19.4 tons per day or 1.76×10^{13} micrograms per day. The maximum average annual concentration of one microgram per cubic meter results in a dispersion reduction factor of $5.68 \times 10^{-14} (m)^{-3}$ day. Table 17 shows the average daily emission of arsenic and cadmium of 9.8×10^{8} and 6.2×10^{7} micrograms per day results in expected average concentrations in the ambient air of 5.6×10^{-5} and 3.5×10^{-6} micrograms per cubic meter, respectively. These are very small concentrations and beyond normal detection limits in a 24-hour sampling period. There is no data which indicates perceptible effects for either arsenic or cadmium at either of these concentrations.

Soil includes a mixture of chemical elements, including trace elements. Table 18 shows a comparison of the representative concentrations of 14 trace elements and sulfur in the soil, with the average concentrations in lignite coal from four mines in this region. The soil averages were determined from soil sampling in the eastern portion of the seven county study area and should not be construed as average throughout the region because of geochemical variations. They will be used in a relative

TABLE 17

PROJECTED ARSENIC AND CADMIUM EMISSIONS FROM LEVEL 1 AND LEVEL 2 PROJECTS IN THE BEULAH VICINITY BURNING AN "AVERAGE"1/ LIGNITE COAL

	Arsenic	Cadmium
Concentration in Coal (Micrograms/Gram)	2.07	0.13
Quantity in Coal Burned2/ (Tons per Year)	39.3	2.5
Emission as Particulate3/ (Micrograms per day)	$9.8x10^8$	$6.2x10^7$

Source: North Dakota State Department of Health 1978

1/ Averages based upon the average composited lignite coal from four mines in this region.

2/ Based upon a total of 19 million tons per year of coal. From Table 1-12 of Draft Study including the ANG coal gasification plant, Antelope Valley power plant, and the Coyote power plant.

3/ As particulate it is assumed that 99% removal will occur in the pollution control devices of the respective projects.

TABLE 18

COMPARISON OF REPRESENTATIVE CONCENTRATIONS OF TRACE ELEMENTS IN THE SOIL WITH THOSE FOUND IN LIGNITE COAL

	Micrograms per Gram (μg/g)	
	Soil Representative Average	Coal Arithmetic Mean
Arsenic	0.42	2.07
Beryllium	0.21	0.75
Cadmium	0.44	0.13
Chromium	0.52	1.29
Copper	0.70	2.88
Fluoride 2/	172.44	15.53
Lead	4/	0.26
Mercury	4/	4/
Molybdenum	4/	1.63
Nickel	4.27	0.93
Selenium	4/	0.30
Uranium	4/	0.47
Vanadium	1.03	2.69
Zinc	7.22	2.56
Sulfur 3/	0.04%	0.72%

Source: North Dakota State Department of Health, 1977.

1/ Soil sampled to a depth of 3 inches. The averages indicated represent soil concentrations in the eastern portion of the seven-county study area.
2/ Data presented as total fluoride.
3/ Data presented as total sulfur, % weight.
4/ Greater than 30% of samples less than detectable limit giving a mean of less than (<) 0.01 limit for Uranium, <0.20 for Selenium, <0.40 for Molybdenum, <0.10 for Mercury, and <0.4 for Lead.

sense to estimate possible increases in ambient air quality levels of arsenic and cadmium.

As shown in this comparison, only cadmium, fluoride, nickel, zinc, and possibly lead are higher in the soil. Windblown soil is the major source of the estimated background particulate air quality concentration of 25 micrograms per cubic meter (on an annual average basis). Using the soil representative averages of 0.42 and 0.44 microgram per gram, respectively, for arsenic and cadmium, the expected average concentration of arsenic and cadmium in the ambient air would be $1.05x10^{-5}$ and $1.10x10^{-5}$ micrograms per cubic meter.

Although this analysis shows that emissions of arsenic would result in a projected five-fold increase in average arsenic ambient air concentration, the significance of this increase is not currently measurable in terms of public health risk because of the low concentrations (in the range of 10^{-5} micrograms per cubic meter) and assumptions made in this analysis. This would also apply to cadmium, although the fraction in ambient air due to soil is projected to be about 4 times that due to coal burning in the Level 1 and Level 2 projects near Beulah.

The size of particles in the ambient air and the pollutants within or adhering to the particle surface are important to any analysis of health effects. Typically, pollution control devices, such as electrostatic precipitators, catch more of the larger particles than the smaller or submicron size (less than 1 micron in diameter) particles. Concern over the smaller particle sizes is due to the entrance and capture of these particle substances in the deeper portions of the lungs, as opposed to the larger particles (greater than 3 microns in diameter) which are

filtered out in the nose and throat and removed from the body via the gastrointestinal system.

In a performance test of an electrostatic precipitator at the Minnkota Power Plant located near Center, the emissions had a particle mass distribution with 50% of the particles smaller than 3.3 microns and 10% less than 1.3 microns. With a total annual particulate emission of 7,075 tons per year from Level 1 and Level 2 projects near Beulah, the total annual atmospheric loading over Mercer and Oliver Counties would be 3,538 tons with a particle size of less than 3.3 microns and 708 tons with a particle size of less than 1.3 microns. From Map 3-4, a fairly uniform distribution of particulate matter is seen, neglecting the influence of localized maximums occurring in the mines associated with these projects.

Examination of the atmospheric loading of particulate matter from areawide sources in Mercer and Oliver Counties (as shown in Table 19) yields a total loading of 40,041 tons per year or 5.7 times the particulate emissions from the Beulah Level 1 and Level 2 facility projects. Unpaved roads, wind erosion, and soil cultivation account for much of the particulate matter in the seven county study area and generally throughout North Dakota.

Very little past data exists concerning the size of particles in the ambient air of North Dakota. In 1977, however, annual particle size data was collected at a commercial site in Bismarck, a rural site north of Bismarck, and a rural site south of Stanton. Figure 4 summarizes the Stanton data for this period. Approximately 90% of the mass of the particles was less than 3.3 microns in diameter and approximately 66% was less than 1.3 microns. This is a comparatively higher percent mass distribution.

TABLE 19

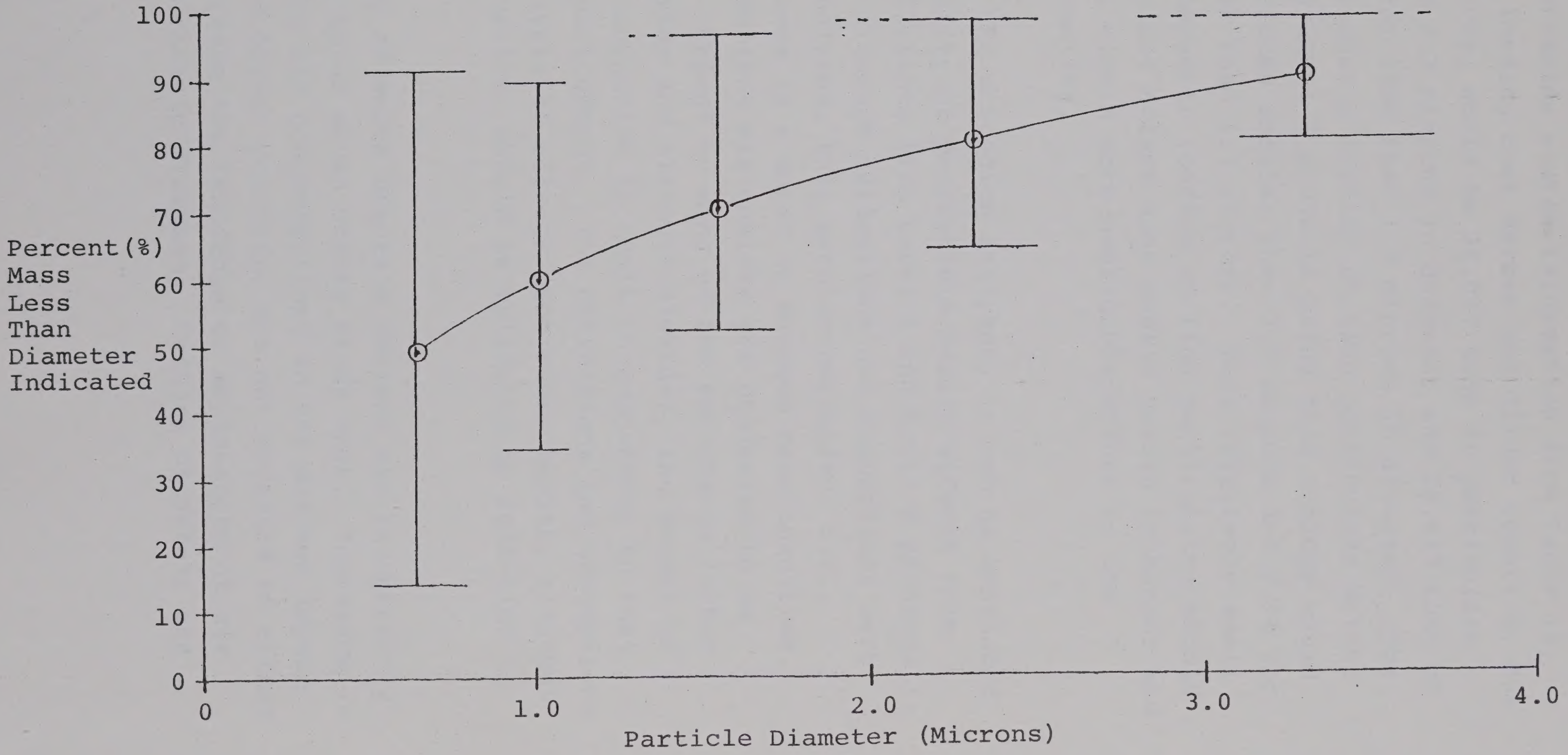
ESTIMATED 1980 PARTICULATE EMISSION FROM AREA-WIDE SOURCES IN MERCER AND OLIVER COUNTIES

	Tons Per Year	
Source	Mercer County	Oliver County
Unpaved Roads	16,180	10,240
Agriculture	3,439	2,551
Construction	835	0
Mining	4,904	1,256
Paved Roads	220	110
Other Sources	205	101
TOTAL	25,783	14,258

Source: U.S. Environmental Protection Agency - North Dakota Air Quality Maintenance Area Analysis (EPA 908/1-76-009) June 1976.

FIGURE 4

WEIGHTED AVERAGE MASS PARTICLE SIZE DISTRIBUTION
STANTON RURAL AIR SAMPLING SITE - 1977



SOURCE: North Dakota State Department of Health, 1978.

Using the areawide source information from Table 19, the atmospheric loading over Mercer and Oliver Counties, due to areawide sources, would be 36,037 tons of particulate matter less than 3.3 microns in diameter and 26,427 tons of particulate matter less than 1.3 microns in diameter. The increase in atmospheric loading of fine particulate matter from Level 1 and Level 2 projects using this analogy would be 9.8% for particles smaller than 3.3 microns and 2.7% for particles smaller than 1.3 microns. This relatively small increase in atmospheric loading of fine particulates should present a negligible effect upon public health in Mercer and Oliver Counties, with a more negligible effect in the broader seven counties.

Based upon the preceding analyses, it can be concluded that the probability of perceptible health effects from emissions of pollutants from Level 1 and Level 2 projects is extremely low. Although estimations and assumptions were used in these analyses, they were conservative; i.e., placing the impacts in a worst or maximum case condition. The impacts on ambient air quality are projected to be small, and with respect to many of the pollutants (other than sulfur dioxide and nitrogen dioxide), the amount of increase of contamination is small in comparison to that already in the environment. The estimations and assumptions used in the analysis of effects upon human health, although believed conservative, should be validated by real-time field studies.

The quality of North Dakota's ambient air is currently good across the total seven county study area. Increases in pollutant ambient air concentrations in the maximum impact area, Mercer and Oliver Counties, are not expected to either perceptibly increase the incidence or seriousness of air quality related chronic diseases. Factors of safety are

provided in the Class II prevention of significant deterioration allowable increments within the seven county study area and the designation by Congress of Class I areas in the Theodore Roosevelt National Park and the Lostwood National Wilderness Area.

Vegetation Effects

Adverse air pollution effects upon vegetation are important to North Dakota because agriculture is the major industry in the state, and adverse effects could impact the economy. Further, adverse effects upon vegetation would result in a reduction in the production of food and fiber for use by people in other areas of the United States and the world.

It has been reported in the news media that a 15% reduction in wheat yield has occurred at levels below the National Ambient Air Quality Standards. The basis for this news account was testimony before Congress. Given the fact that the cost of wheat production has risen with inflation while the market price for this commodity has not, a 15% reduction in wheat yield (barring hail, rust, and other risks associated with wheat farming) would be a substantial economic loss. This specific example was referenced to in the Legislative History of the Clean Air Act (U.S. Code, Congressional Administrative News, 95th Congress, 1st Session 1977, Legislative History). To quote from page 1207 of this Legislative History:

> "The evidence is strong that air pollutants have damaging effects on crops at levels below the National Standards. For example, studies show that important agricultural crops suffer leaf damage, growth inhibition, or increased mortality resulting from sulfur dioxide levels lower than the national ambient air

> quality standards. These effects may result in a substantial economic impact such as the reported 15% reduction in wheat yield at a sulfur dioxide exposure level of less than half the national standard (Guderian, R. and H. Shatmann, Forschungsber, Landes Nordrhein-Westfaler 1920:3, 1968). Since much of the United States where wheat is grown has sulfur dioxide pollution levels below half the national standard, the importance of not allowing air quality to deteriorate to the standard is clear."

Concern over the question of a 15% wheat yield reduction from levels of sulfur dioxide at half the allowable national level is justified particularly in view of media accounts which relate this "alarming" information to the Great Plains States where the "massive" use of coal is scheduled. The reader is left with the impression that this sort of cause-effect relationship will occur in the Great Plains, and North Dakota specifically. The concern is justified; however, the presumption of this cause-and-effect relationship is not indicated.

Various species of vegetation appear to be more sensitive than others. Other factors to be considered in predicting cause-effect injury to vegetation from air pollution is the environment in which the plants are growing, the expected pollution concentration, and the fequency and duration of exposure. There are many environmental factors which affect vegetation response and growth, including climatic factors, light quantity and quality, temperature, relative humidity, soil type, and soil nutrition. Various species of vegetation may be more sensitive to one pollutant than another pollutant. The interaction of more than one pollutant acting in a synergistic effect should also be considered.

Much attention in the scientific literature on vegetation effects has been directed to sulfur dioxide and other phenomena such as acid rainfall. (A following section will consider the effects of acid railfall. This discussion of vegetation effects will focus on sulfur dioxide.) Table 20, which shows agricultural damage, has been reproduced from the Legislative History (page 1208) of the Clean Air Act. There are a number of crops in this table that are of special interest to North Dakota.

The summary of sulfur dioxide concentration-duration-effects shown in Table 20 was derived from studies, the validity of which may be subjected to scientific review. To examine the vegetation effects of sulfur dioxide emissions from Level 1 and Level 2 projects, it will be assumed that the study results are valid.

With respect to sulfur dioxide ambient air quality standards, the North Dakota standards are more stringent than Federal standards. A side-by-side comparison of standards was shown earlier in Table 12. The concentration-duration for apparent prevention of slight leaf necrosis in barley would be above the state's 1-hour standard of 715 micrograms per cubic meter and, therefore, the state standard should prevent such effect. The other effects noted, assuming the study results are valid, would occur at concentrations-durations lower than the present State ambient air quality standards.

In the Draft Study, the point was made that the projected increase of sulfur dioxide in the atmosphere from Level 1 and Level 2 emissions was well within State ambient air quality standards. This followed a detailed analysis of how much increase was projected. The expected maximum ambient air quality values, including projected increases

due to emission of sulfur dioxide, were shown in Table 13. These maximum sulfur dioxide values are 7.5 micrograms per cubic meter--maximum annual mean; 55.8 micrograms per cubic meter--24-hour maximum; 113.5 micrograms per cubic meter--3-hour maximum; and 231.1 micrograms per cubic meter--1-hour maximum. The time periods referred to are the averaging periods.

The expected maximum ambient air concentrations noted above from Level 1 and Level 2 projects are well below the concentration-duration values shown in Table 20. It should be noted that these maximum concentrations are expected to occur in Mercer and Oliver Counties and within approximately 8 miles of Beulah. Further, these are maximum values with the average short-term (less than annual) values less than those shown in Table 13. This is evident in Table 9 which found that 96.6% of the 1-hour continuous samples were in the range of 0 (not absolute zero) to 26.2 micrograms per cubic meter. Further, sulfur dioxide emissions from the Stanton plants are approximately 1,500 tons per year more than the Level 1 and Level 2 projects in the Beulah vicinity.

Specifically, with respect to the question of reduction in wheat yield, no perceptible reduction in wheat yield is expected to result from the emission of sulfur dioxide from the Level 1 and Level 2 Beulah projects. The expected annual average ambient air concentration of 7.5 micrograms per cubic meter (including the Beulah projects) is considerably less than the 39.2 micrograms per cubic meter value shown in Table 20 for wheat. The respective State and Federal annual mean standards are 60 and 80 micrograms per cubic meter, respectively. Even taking into account the fact that the growing season for wheat is from May through August (a shorter averaging period than annual), and

TABLE 20

AGRICULTURAL DAMAGE AT SULFUR DIOXIDE LEVELS BELOW THE NATIONAL EXPOSURE

Ref.	Plant	SO_2 CONC. ($\mu g/m^2$)1/	Duration of exposure	Effects
4	Oats	26.2	Growing season	Slight leaf necrosis.
3	Barley	967.0	2 to 3 hours	Slight leaf necrosis 2d day.
3	- - - - - - - - -	362.0	4 hours	Slight leaf necrosis 4th day.
5	Wheat	39.2	Growing season	15 percent decrease in grain yield weight.
1	Peanut	2.4-78.6	4 to 5 hours	Slight leaf chlorosis.
1	- - - - - - - - -	131.0-314.0	4 to 14 hours	Slight leaf discoloration.
9	Soybean	131.0	4 hours	Do.
4,5	Alfalfa	23.6	Growing season	Leaf discoloration & necrosis.
3	Kidney bean	131.0	4 hours	2 percent leaf discoloration.
9	Radish	131.0	do	Slight leaf necrosis and chlorosis.
5	Potato	39.3	Growing season	Decrease in tuber yield weight.
4	Spinach	23.6	do	Leaf necrosis.
4	Red clover	23.6	do	Do.
4	Orange	39.3-62.9	do	Decrease in yield quantity and in thickness growth.
5	Sour cherry	62.9	do	Decrease in yield weight.
4	English oak	62.9	do	Decrease in thickness and cross-sectional growth area.
7	Spruce	55.0	8 months	Leaf injury.
7	- - - - - - - - -	62.9	Growing season	Decrease in thickness growth.
2	Pine	21.0	10 yr growing season	2.5 to 37.5 percent leaf injury, increase in mortality.
6	- - - - - - - - -	23.6	do	6.0 to 43.2 percent leaf injury.
6	- - - - - - - - -	44.5	do	21 to 77 percent leaf injury, leaf abscission decrease in yield volume, increase in mortality.
8	Tobacco	655.0	2 hours	Damage.

SOURCE: U.S. Code, Congressional Administrative News, 95th Congress, 1st Session 1977, Legislative History - page 1208.

NOTE: For reference, National Ambient Air Quality Standards for sulfur dioxide are: Primary--80 $\mu g/m^3$ annual average, 365 $\mu g/m^3$ annual maximum. Secondary--1,300 $\mu g/m^3$ 3-hour annual maximum.

1/ The sulfur dioxide concentration units are presented as they are found in the source. It is believed that the units should be $\mu g/m^3$ rather than $\mu g/m^2$ indicated.

$\mu g/m^3$ = micrograms per cubic meter

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perceptible wheat yield reduction would not be expected in the maximum impact area of Mercer and Oliver Counties or in the broader seven county study area.

The particulate and nitrogen dioxide emissions from the Level 1 and Level 2 projects would, likewise, not be expected to result in a perceptible effect upon vegetation in the seven county study area, given the concentrations projected and the expected frequency of occurrence and duration.

A number of other pollutants have been linked to vegetation effects including ozone, hydrogen chloride, ethylene, ammonia, carbon monoxide, and heavy metals. These fall into the category of minor pollutants from the Level 1 and Level 2 projects in the Beulah vicinity. Although a perceptible effect upon vegetation is not expected due to these pollutants in the ambient air of the seven county study area, additional monitoring, study, and analyses of potential effects is indicated. The long-term effects of heavy metals (trace elements) is now currently under study by the North Dakota State Department of Health.

The knowledge of effects upon vegetation from the synergistic interaction of multiple pollutants at the present time is, at best, inconclusive and fragmentary. These interactions are complex and not readily determined. Examination of the apparent lack of perceptible vegetation effects in the vicinity of the Stanton facilities would indicate a low risk of vegetation effects in the vicinity of Beulah where the maximum air quality impact is expected to occur.

The quality of North Dakota ambient air is currently good across the total seven county study area. Increases in

pollutant ambient air concentrations in the maximum impact area, Mercer and Oliver Counties, are not expected to result in perceptible vegetation damage. Factors of safety are provided in the Class II prevention of significant deterioration allowable increments within the seven county study area and the designation by Congress of Class I areas in the Theodore Roosevelt National Park and the Lostwood National Wilderness Area.

Animal Health Effects

Historical air pollution effects upon animals have been documented. These problems were due to gross contamination of the environment over relatively few years of operation of various pollutant sources. A characteristic of these sources was inefficient pollution control equipment, by today's standards. Further, the effects were observed to occur near the polluting source.

In view of the projected increases, shown in Table 13, of the major pollutants (particulate matter, sulfur dioxide, and nitrogen dioxide) resulting from emissions from Level 1 and Level 2 projects in the Beulah area, there is no indication of potential health effects. A comparison of the sulfur dioxide expected ambient air concentration in the Beulah area with measured concentrations near Stanton would indicate no effects upon animal health due to sulfur dioxide. As was pointed out earlier, the atmospheric loading of sulfur dioxide from existing Stanton power plants is approximately 1,500 tons per year more than the Level 1 and Level 2 projects at Beulah. No animal health effects have been observed in the vicinity of the Stanton power plants from exposure of animals to sulfur dioxide.

As was discussed earlier under Human Health Effects, the quantity of particulate matter from the Level 1 and

Level 2 projects is much less than the atmospheric loading of particulate matter from the areawide sources of unpaved roads and agricultural operations. Further, the sizing of particulate matter from areawide sources showed a higher percentage in the respirable and submicron range.

Although the expected maximum nitrogen dioxide ambient air concentration (including the Level 1 and Level 2 projects) is shown to be high, this maximum is expected to occur only 0.001% of the time. An animal health effect would not be expected to occur at this concentration-duration of nitrogen dioxide. Further, the maximums are expected to occur within eight miles of Beulah.

Animal health, like human health, is influenced by the environment. Also, like humans, animals are subject to chronic diseases. Factors in the environment which relate to an animal's health and nutritional growth include substances in food, air, and water; and physical stress caused by changes in weather, severe weather, insects, and other related aspects.

Since a large sector of the agricultural economy of the seven county study area is dependent upon cattle raising, concerns have been expressed about animal health effects of Level 1 and Level 2 projects. Concern has been specifically directed to molybdenosis and selenium-responsive diseases in cattle. Although direct animal health effects are not expected from the three major pollutant emissions of Level 1 and Level 2 projects, it is appropriate to examine questions related to animal diseases such as molybdenosis and selenium-responsive diseases.

Both referenced and animal diseases are not due to a direct acute reaction to pollutants in the environment.

Rather, these animal health effects are related to the animal's food chain, in the case of molybdenosis, with an apparent similar relationship in the case of the selenium-responsive diseases. The North Dakota State Department of health has been actively involved in both of the referenced cases and is currently researching the trace element effects of energy conversion facilities. This research activity is discussed under "Trace Element Effects."

As with human health, animal health is a function of nutrition. Trace elements play a major role in the growth and maintenance of an animal. Trace elements have been defined in various ways, for example, any chemical element in a substance with a concentration of less than 1,000 parts per million. This then, depending upon the substance of interest, could include many of the 92 naturally occurring chemical elements. Trace elements are in the air, soil, water, and everything which lives in the environment. Some trace elements have been referred to as "essential trace elements;" i.e., essential to the nutrition of the animal. These chemical elements, if they are in proper balance within the animal, will result in a healthy animal. Conversely, if an imbalance in the essential chemicals is occurring, the result is an unhealthy animal. Too much of an essential element can cause a toxic reaction; whereas, not enough of the chemical can cause a deficiency reaction. Either of these reactions can result in poor health and even death of animals.

Molybdenosis in animals is a prime example of a toxic/deficiency disease. The problem in North Dakota was caused by an excess of molybdenum in the food chain which resulted in an apparent copper deficiency. This problem is described in a report prepared by the North Dakota State Department of Health (Christianson and Jacobson 1970).

In September of 1968, the North Dakota State Department of Health was contacted by an attorney in Bowman and asked to evaluate an unusual problem which had arisen on a farm in that vicinity. Animals on this farm were stated to be in poor condition with excessive weight loss and severe diarrhea. Further, the cattle on this farm were changing color, from black to gray. The State Department of Health was called, since the farm in question surrounded a plant site used to ash uraniferous lignite coal, a low grade coal with high uranium content.

The plant operation consisted of the stockpiling of lignite coal from the Cave Hills area of South Dakota and upgrading the uranium content in the lignite coal by "ashing" in rotary kilns. The three kilns had a total capacity of 225 to 250 tons of material per day. This plant operated at this site from July of 1963 to May of 1967. This ash was shipped out-of-state for further processing to nuclear power reactor fuel.

The symptons described had the vague semblance of radiation involvement with the severe intestinal disturbance and change in hair color. The Department initially approached this problem from the standpoint of environmental radiation exposure of the farm animals. The levels of external radiation exposure to the animals and the radioactive materials in the animal diet did not indicate a problem related to radiation. This was followed by investigation of the possibility of an infectious disease or chemical involvement. A chemical, specifically molybdenum, was shown, subsequently, by the Department to have caused the disease in the animals on this farm.

The Bowman molybdenosis syndrome found in the Department's investigation was determined to result from soil

contamination by the uraniferous ashing plant. The contamination of the soil used for the grazing of cattle and sheep on this farm and the subsequent entrance into the animals via forage uptake resulted in losses both in deaths of animals and lost revenues through weight loss of the surviving animals. The short-term economic losses to the farming operations on this farm are assessable; however, there still remain some unanswered questions to this problem. It is not known how long this condition of soil contamination will remain a problem to this farm.

It is possible that this farm can eventually return to normal through depletion of the molybdenum concentration in the soil with crop removal, leaching action within the soil, or reduced availability through soil complexing of the molybdenum. In any event, a sophisticated study to determine answers to these questions is not within the financial resources of the State Department of Health. Interim grazing operation on this farm suggests the employment of copper glycinate injections or substitution of pasture grazing on this farm for the drylot feeding of cured hay and feeds.

The uraniferous lignite ashing plant operated at this site for approximately four years. It began operation approximately seven years before North Dakota had an air pollution control law. A uraniferous lignite facility designed with the pollution control devices, such as were used at this facility, would not be allowed to construct in North Dakota under the present rules and regulations of the Department. Another uraniferous lignite ashing facility operated with better pollution control equipment at about the same time in the Belfield vicinity without apparent animal effects. The Belfield facility, although utilizing better air pollution control devices, probably would not

meet today's requirements under the State's air pollution control rules and regulations.

The soil of the Bowman farm apparently is still contaminated with molybdenum, making management of cattle and sheep expensive and difficult. If the present State Air Pollution Law, rules, regulations, and standards had existed in 1963, this problem probably would not have occurred.

Very little is known about the chemical composition of the uraniferous lignite coals other than the uranium concentration, which is discussed under "Radiation Impact." All that remained at the Bowman plant when the Department was called was a partially disassembled plant and no coal. Samples of ash material remaining in the dust collectors of this plant were found to contain 3,200 parts per million of molybdenum. Although it is questionable that this is a representative sample, it clearly indicates a high concentration of molybdenum in the ash and very likely in the coal.

The characteristics of the uraniferous lignites processed in these ashing plants would not be suitable for use as fuel in the Level 1 and Level 2 energy conversion facilities. These coals were highly mineralized and found in veins varying in thickness from one-half inch to four feet. After the overburden was removed, the mining operation involved hand shovels and small front-end loaders. The coal varied in rank from 1,000 to 5,000 Btu/lb compared to an average of approximately 7,000 Btu/lb proposed for use in the Level 1 and Level 2 Beulah projects. Natural gas had to be used in the ashing plants to assist the burn and drive off the 32 to 52% moisture content present in these coals.

The lignite coals proposed for use in the Level 1 and Level 2 projects, as might be expected, do contain molybdenum; however, by comparison to the uraniferous lignites, the concentration is very low. Lignite coal sample analysis from four mines in central North Dakota, done by the State Department of Health (Trace Element Effects of Energy Conversion Facilities 1977), yielded a coal molybdenum concentration range of 0.64 to 6.4 micrograms per gram with an arithmetic average of 1.63 micrograms per gram. For purposes of comparison, the maximum value of 6.4 micrograms per gram will be used.

With a molybdenum concentration of 6.4 micrograms per gram, an assumed ash content of 6%, and assuming that the molybdenum is concentrated in the fly ash, the molybdenum in the Level 1 and Level 2 project ash would be 10.67 micrograms per gram or 10.67 parts per million. This is about 1/300 of the concentration in the ash found at the Bowman plant. It should again be emphasized that the Bowman plant had a relatively inefficient pollution control system in comparison to the devices designed for use on the Level 1 and Level 2 projects. It is highly unlikely that any emission of molybdenum from Level 1 and Level 2 projects would result in molybdenosis in livestock in the Beulah vicinity, the maximum air quality impact area, even though the coal utilization would be greater and the plants would be expected to operate for 40 years.

There is considerable documentation of direct acute effects of air pollutant emissions upon human health, materials, and vegetation. Cause-effect relationships form the foundation of federal and state air pollution control regulations. Indirect effects, to date, have generally received less attention due to the complexity of analysis and the lack of definitive documentation of cause-effect

relationships. In order to satisfy energy needs without severe and unnecessary impacts upon the environment, the indirect as well as direct cause-effect relationships must be examined for possible mitigation actions, as appropriate.

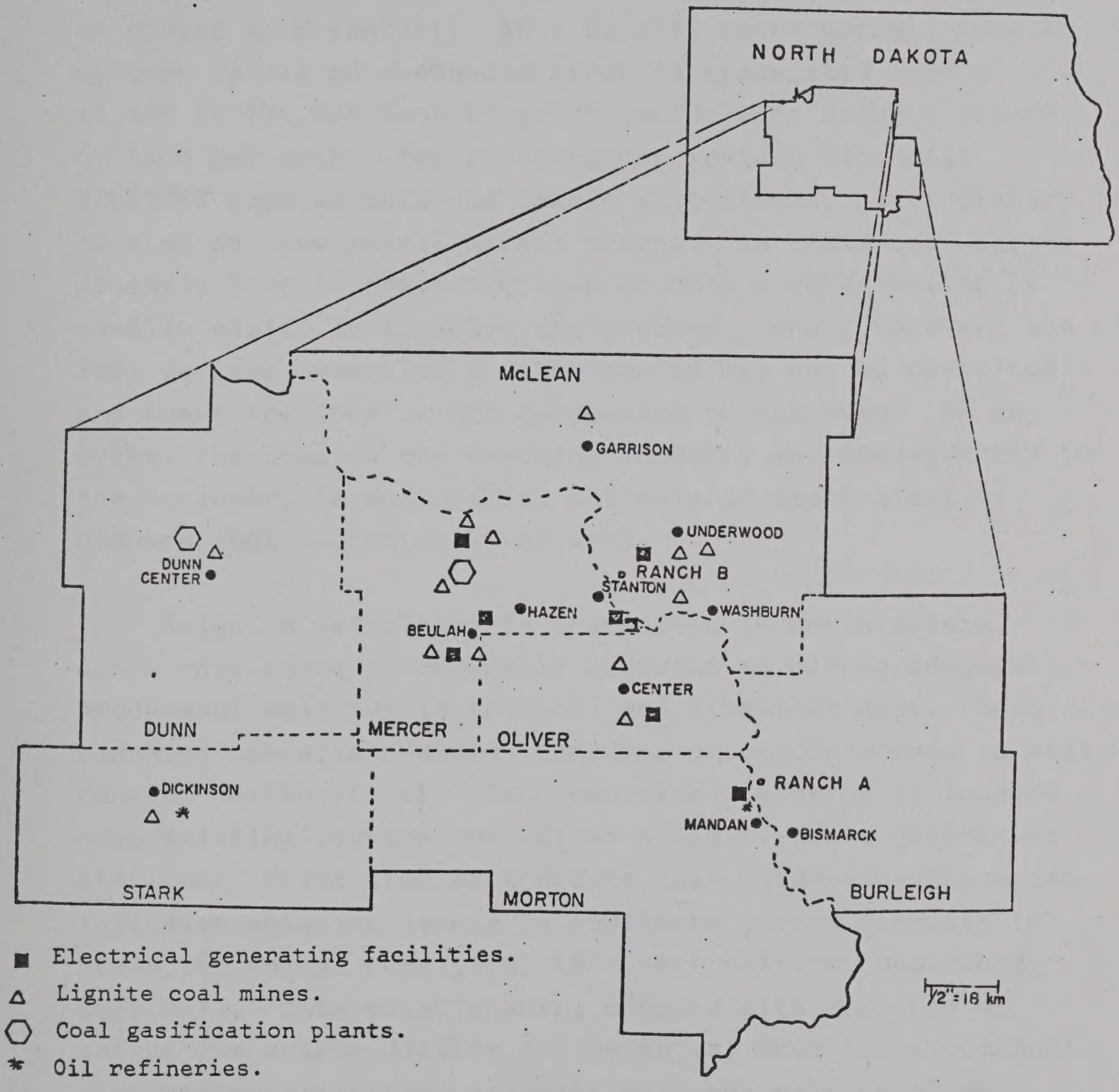
All of the proposed sites for energy conversion facilities in North Dakota are located in rural areas. A major focus of the North Dakota Department of Health is the environmental effects of energy conversion facilities upon these rural areas and subsequently upon the agricultural economy of these areas.

In recent years there has been a clinical manifestation of a cattle disease in newborn calves which demonstrates skeletal-muscle myopathy (white muscle disease) in localized areas of western North Dakota. Preliminary investigation, performed over the last four years by a practicing veterinarian, have revealed that the occurrence of this disease may be due to the interaction of sulfur and selenium as they relate to animal health and nutrition.

Two cattle ranching operations approximately 65 kilometers (40 miles) apart (shown in Map 4) have experienced losses of newborn calves: 10-30% at one ranch and approaching 100% at the other before a selenium responsive disease was diagnosed. Normal expected calf losses are on the order of 2-3%. In both cases the dead calves displayed, by gross pathology and histopathology, a similar skeletal myopathy. The myopathy is associated with a metabolic deficiency of selenium, as element which is a part of the body enzyme, glutathione peroxidase. Subsequent to diagnosis of selenium disease, these problems were reversed with an injection of a selenium pharmaceutical (selenium plus vitamin E). The animal disease is now controlled by the feeding of a small amount of a good biological source of

MAP 4

LOCATIONS OF EXISTING AND PROPOSED AIR CONTAMINANT SOURCES


NORTH DAKOTA
McLEAN
GARRISON
UNDERWOOD
RANCH B
STANTON
WASHBURN
HAZEN
BEULAH
CENTER
DUNN CENTER
DUNN
MERCER
OLIVER
DICKINSON
RANCH A
MANDAN
BISMARCK
STARK
MORTON
BURLEIGH
1/2" = 18 km

■ Electrical generating facilities.
△ Lignite coal mines.
⬡ Coal gasification plants.
* Oil refineries.

SOURCE: North Dakota State Department of Health, 1977.

Bad
[illegible] original)

available selenium, wheat or wheat bran, during the last 60 days of pregnancy.

Calf losses of the magnitude described above are a loss of income to a rancher. An 8 to 27%, above normal, loss in newborn calves on a 400-cow ranch is translated into a $6,400 to $21,600 loss in gross income when using a figure of $200 per calf. Few ranchers can sustain financial setbacks such as this and remain in business, particularly in view of live animal market proces. In instances where a dramatic loss in newborn calves occurs, a veterinarian is usually called in to solve the problem. When, however, the loss is less dramatic, a veterinarian may not be consulted and hence the loss is not documented or resolved. In any event, the loss to the ranching industry and subsequently to the consumer, is measurable, not only in statistical numbers, but economically as well.

Selenium deficiency is unexpected in North Dakota, since this state is generally regarded as having adequate amounts of selenium in the soil and livestock diet. Both ranching operations employ ranching practices common to west central United States. Each ranching operation is located near existing lignite coal-fired steam electric generating stations. Prior studies indicate that ingested sulfate can influence selenium levels in ruminants (Trace Elements in Human and Animal Nutrition, 1977, 4th Edition, Underwood, page 324). This relationship, coupled with a source of sulfur (as sulfur dioxide and sulfates) from the electrical generating facilities, suggests that the calf problems experienced on these two ranches, separated by some 65 kilometers, may be due to increased sulfur in the environment or food chain as a result of emissions from energy conversion facilities (Sulfur Metabolism of Plants, Industrial and Engineering Chemistry, 1950, Vol. 45, pages 2231-2235, Thomas, Hendricks, and Hill).

The electrical generating facilities in question are not large by comparison with the design capacity of sources being permitted for construction and beginning operation in the United States today. Ranch A is located within 2 kilometers (1.2 miles) of an existing generating station of approximately 100 megawatts. A generating complex approximately 10 kilometers (6 miles) from Ranch B (Stanton area), prior to diagnosis of the problem, had a design capacity of approximately 400 megawatts. At the present time, the operating capacity near Ranch B is approximately 800 megawatts. The Level 1 and Level 2 Beulah power plants will have more than twice (1760 megawatts) the electrical generating capacity of the Stanton plants. However, including the sulfur (as sulfur dioxide) emissions from all Level 1 and Level 2 projects in the Beulah vicinity will be approximately 1500 tons per year less than in the Stanton area.

The only fact known at either Ranch A or Ranch B is that they have experienced a selenium-responsive disease; i.e., a disease corrected with selenium treatment. It is now known whether this disease is caused by excess sulfur in the diet, by animal stress in the last 60 days of pregnancy, by lack of biological availability of natural selenium in the diet material, or some other cause. One common error in logic is to assume that two phenomena that occur concurrently and side-by-side must be connected with one another in a cause-effect relationship. The environment is too complicated for a direct-simple analysis such as this. There is sufficient justification, however, to consider sulfur as the possible cause of the disease noted at Ranch A and Ranch B. Only through a study of the sulfur/selenium environmental balance and the effects of energy conversion facilities upon this balance, can a cause-effect relationship be established or discounted.

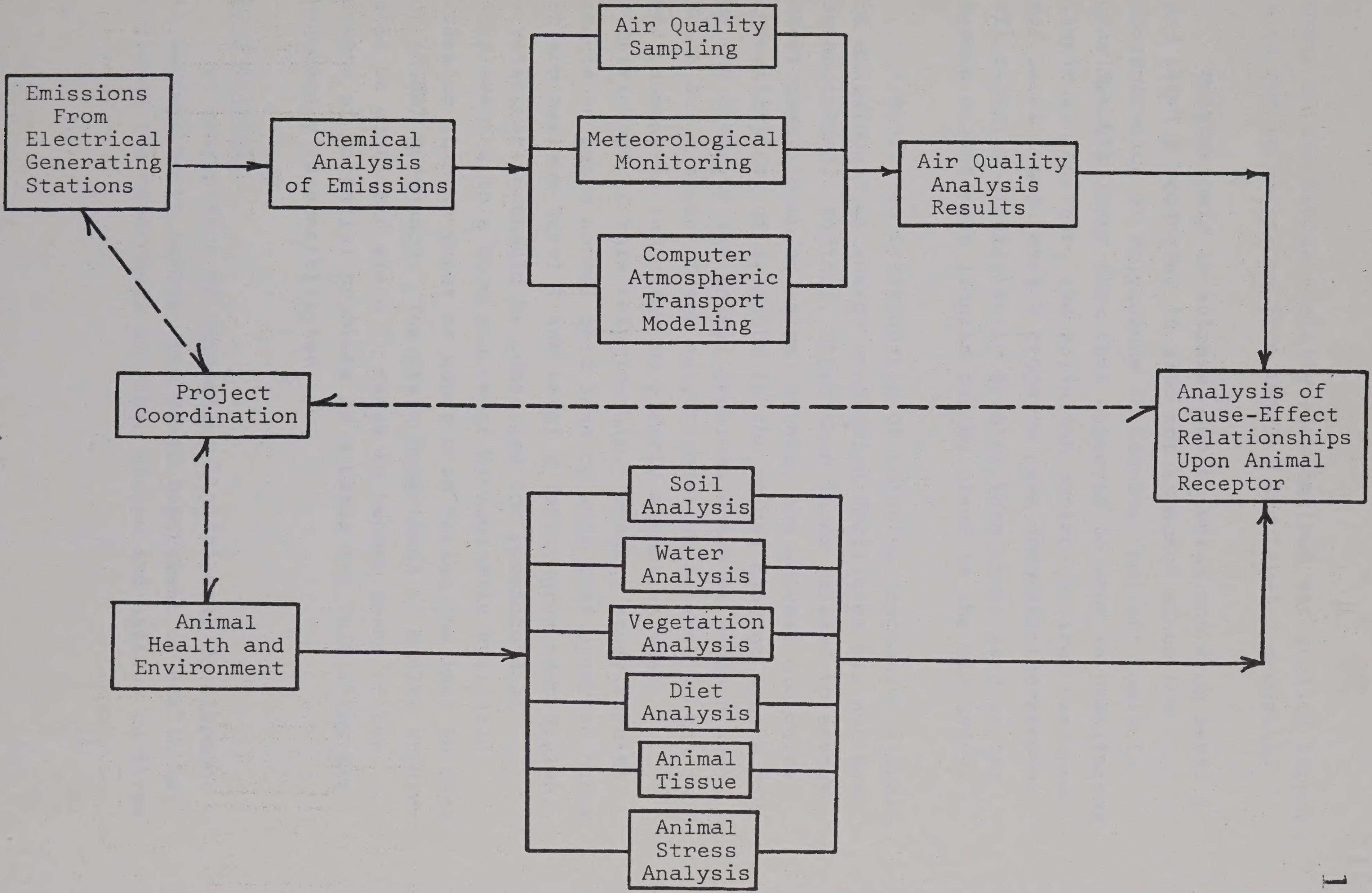
In view of the growth and development of coal-fired electrical generation in North Dakota and in a broader sense, the United States, studies need to be undertaken to determine, for possible mitigation action, the potential for increased environmental sulfur resulting in the incidence of selenium responsive diseases in cattle. This involves analysis of two possible hypotheses for this unknown: (1) if the increased levels of environmental sulfur are shown to cause a selenium deficiency in cattle, the present national sulfur (sulfur dioxide) emission control and ambient air quality regulations would be examined for appropriate numerical reduction; and (2) if the increased levels of environmental sulfur are not shown to cause a selenium deficiency in cattle, this study should examine other possible cause-effect relationships in explanation of why a selenium responsive disease has occurred in two ranching operations and not at other ranches.

A study to resolve the two hypotheses noted above is expensive, and would take at least two or possibly three years of intensive scientific work to answer, due to the complexities involved. Some of the complexities are indicated in the analysis pathways shown in Figure 5. The study must employ a team of specialists working in close coordination. The North Dakota State Department of Health has been unsuccessful in attempts to obtain the funds necessary to perform this study. Even if sulfur is not related to the selenium responsive disease observed at Ranch A and Ranch B, this study would add much to the knowledge of the environment and aid in the protection of animal health.

In view of the relatively smal projected increases in ambient air concentrations of the three major pollutants, particulate matter, sulfur dioxide, and nitrogen dioxide, no observable direct animal health effects are expected to

FIGURE 5

Analysis Pathways


Emissions From Electrical Generating Stations
Chemical Analysis of Emissions
Air Quality Sampling
Meteorological Monitoring
Computer Atmospheric Transport Modeling
Air Quality Analysis Results
Project Coordination
Analysis of Cause-Effect Relationships Upon Animal Receptor
Soil Analysis
Water Analysis
Vegetation Analysis
Diet Analysis
Animal Tissue
Animal Stress Analysis
Animal Health and Environment

occur in the Beulah vicinity, the maximum air quality impact area due to emissions from Level 1 and Level 2 projects.

Molybdenosis in animals, due to emissions from Level 1 and Level 2 projects, is also not expected since the concentration of molybdenum in lignite "boiler" coals is considerably lower than that expected to ccur in uraniferous lignites. Further, the pollution control devices designed for Level 1 and Level 2 projects have demonstrated removal efficiencies significantly greater than those used at the Bowman uraniferous lignite ashing plant in the mid-1960s.

A confirmed relationship of selenium responsive disease to emissions from energy conversion facilities has not been demonstrated. Factors, other than those related to energy development, such as animal stress, the natural biological inavailability of selenium in the animal diet or others may be the cause of the animal problems noted at Ranch A and Ranch B. A study of the sulfur/selenium balance in the environment is indicated to clearly establish the significance of this relationship. Pending study results, should an above normal calf loss or weak calf syndrome occur in the maximum Level 1 and Level 2 impact area near Beulah, a veterinarian should be consulted for possible diet supplement with a good source of biologically available selenium such as wheat or wheat bran during the last 60 days of animal pregnancy. The State Department of Health should also be contacted since it needs to become aware of the extent of potential problems as a basis for fulfilling its regulatory responsibilities.

Acid Rainfall

In recognition of increasing lignite coal development in western North Dakota, the State Department of Health has reviewed the experience of other states and nations in terms

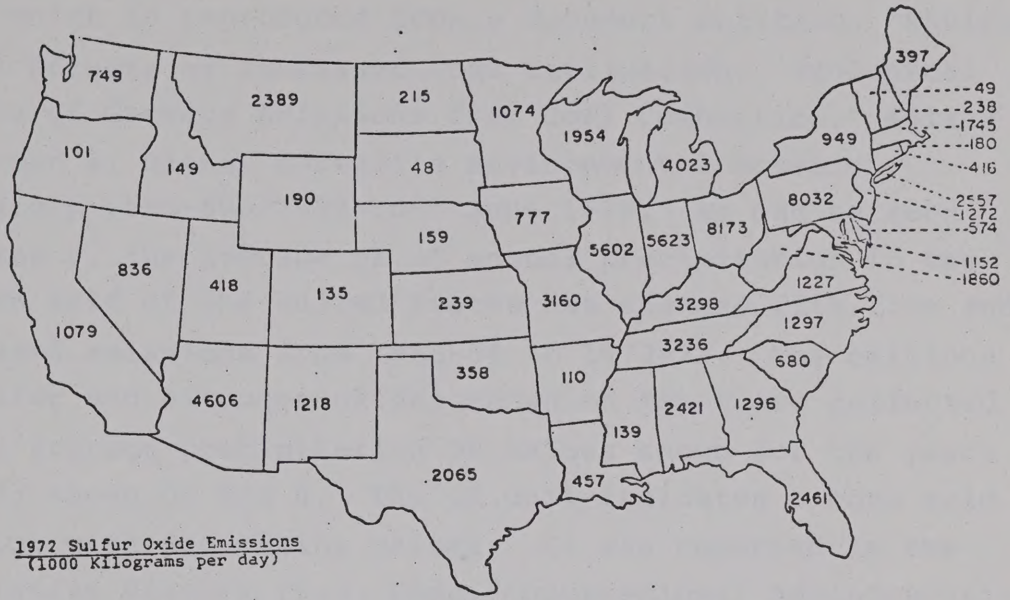
of deleterious environmental impacts resulting from industrial development. This examination involved case histories of after-the-fact problems; problems which were either not expected, or which resulted from inadequate control of emissions.

Problems experienced with acid rain have been reported from northwestern Europe (Oden, S. 1976; Overrein, L. 1976; Nordo, J. 1976: Ottar, B. 1976; Semb, A. 1976; and Klackow, D. and H. Denzinger 1976), northeastern United States (Jacobson, J. et al. 1976; Boyce, S. and S. Butcher 1976; Cogbill, C. 1976; Likens, G.E. and F.H. Bormann 1976; and Likens, G.E. et al. 1972), and Canada (Hutchingon, T.C. 1976; Nyborg, M. and J. Crepin 1976; and Baker, J. et al. 1976).

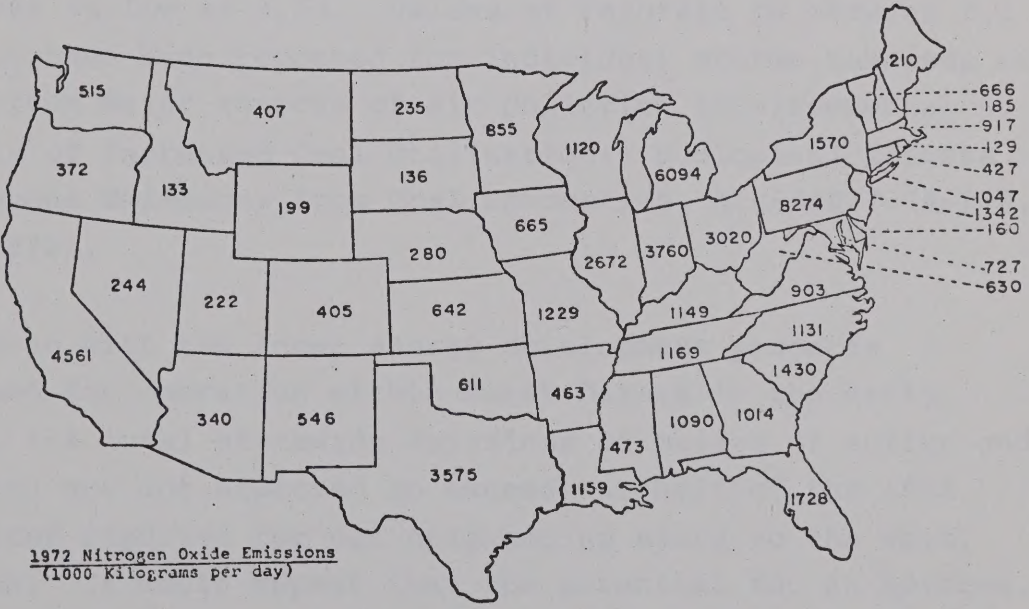
In North Dakota, the only recorded corrosive atmosphere problems occurred during the 1960s in the oil and sour gas production areas of the northwestern corner of the state. Farm machinery and metal farm buildings were apparently damaged by sulfurous gases in combination with water vapor. These problems occurred prior to an air pollution control law in North Dakota, and industry voluntarily corrected them. The primary chemical compounds attributed to causing acid rainfall are oxides of sulfur and nitrogen.

The potential for the problems in northeastern United States are evident in Map 5. This map presents a geographic picture of the emissions of oxides of sulfur and nitrogen, by state, for 1972 (the last year that the Department could obtain national data). In addition, it was reported by Hutchinson 1976 that the annual emissions of sulfur dioxide from smelters in the Sudbury, Ontario, area of Canada were in excess of three million tons in 1972.

MAP 5
NATIONWIDE EMISSIONS OF SULFUR AND NITROGEN--1972
(metric tons per day)


749
2389
215
1074
397
49
238
1745
180
416
101
149
48
1954
4023
949
190
777
8032
2557
1272
574
159
5602
5623
8173
1152
1860
836
418
135
239
3160
3298
1227
1079
1297
3236
358
110
680
4606
1218
2421
1296
139
2065
457
2461

1972 Sulfur Oxide Emissions
(1000 Kilograms per day)


515
407
235
855
210
666
185
917
129
427
372
133
136
1120
6094
1570
1047
1342
160
199
665
8274
280
2672
3760
3020
727
630
244
222
405
642
1229
903
1149
4561
1131
1169
1430
611
463
340
546
1090
1014
473
3575
1159
1728

1972 Nitrogen Oxide Emissions
(1000 Kilograms per day)

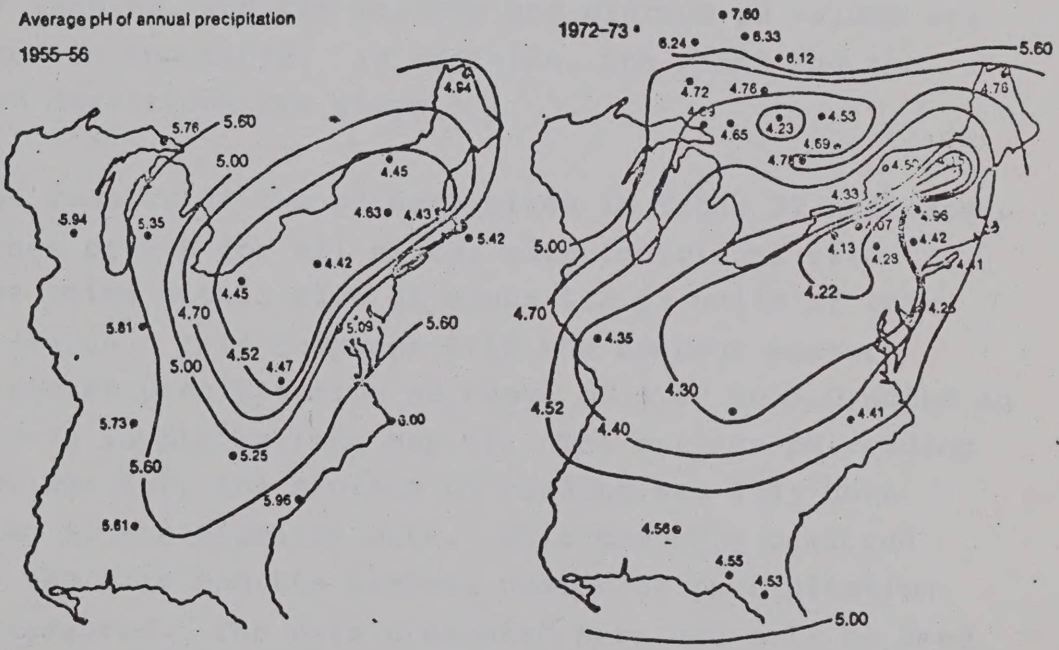
Source: 1972 National Emissions Report
U.S. Environmental Protection Agency
EPA-450/2-74-012 (June 1974)

The relationships of these sulfur oxide and nitrogen oxide emissions, by state, to the pH of rainfall is seen in Map 6 which is reproduced from a document entitled, "Environmental Effects of Increased Coal Utilization: Ecological Effects of Gaseous Emissions from Coal Combustion," edited by Norman R. Glass, Corvallis Environmental Research Laboratory (EPA-600/7-78-108) June 1978. As can be seen from Map 6, the average pH of annual precipitation in the eastern half of the United States has changed with time and increased emissions from 1955-56 to 1972-73. The emisions of sulfur and nitrogen oxides shown on Map 5 are reflected in the average precipitation pH values shown for the years 1972-73 shown on Map 6. The pH unit indicates a more acid solution with decreasing values. It was reported in the Legislative History (U.S. Code, Congressional Administrative News, Legislative History, 95th Congress, 1st Session, page 1209) of the Clean Air Act Amendments of 1977 that in Ithaca, New York, in June-July of 1971, the average pH of rain was as low as 3.53. Values of rainfall pH between 2.1 and 3.6 have been reported for individual storms hundreds of miles from major sources of air pollution (Environmental Effects of Increased Coal Utilization: Ecological Effects of Gaseous Emissions from Coal Combustion, EPA-600/7-78-108, June 1978).

Even with the known energy development projects proposed for operation within North Dakota in the early 1980s, the total statewide emissions of oxides of sulfur and nitrogen are not expected to exceed one half of the 1972 emissions reported for our neighboring state to the west, Montana. It would appear that the potential for an adverse, or eipsodic acid rain problem is low in North Dakota. However, one cannot entirely rule out localized problems developing in areas of more intensive energy development or under stable atmospheric conditions.

MAP 6

TIME COURSE OF CHANGE IN pH ISOPLETHS FROM 1955-56 TO 1972-73 IN THE NORTHEASTERN UNITED STATES


Average pH of annual precipitation
1955-56
5.76
5.60
5.00
4.64
4.45
4.63
4.43
5.42
5.94
5.35
4.42
4.45
4.70
5.81
5.09
5.60
4.52
4.47
5.00
5.73
6.00
5.25
5.60
5.96
5.61
1972-73 a
7.60
6.24
6.33
6.12
5.60
4.72
4.76
4.78
4.69
4.65
4.23
4.53
4.69
4.78
4.33
4.96
4.07
4.13
4.28
4.42
4.41
4.22
4.25
5.00
4.70
4.35
4.30
4.52
4.40
4.41
4.56
4.55
4.53
5.00

Source: G. E. Likens and C. V. Cogbill

From: C & E News, November, 1976

a Data from Oak Ridge, Tenn., for 1973–74; data from Tallahassee, Fla., for 1974–75; and from Gainesville, Fla., for 1976. Source: Various, including C. V. Cogbill, Thomas Burton, Patrick Brezonik, and Gary Henderson

Source: U.S. Environmental Protection Agency
Environmental Effects of Increased
Coal Utilization: Ecological Effects
of Gaseous Emissions From Coal Combustion
(EPA-600/7-78-108) June 1978

It is important, in view of North Dakota's agricultural economy, to protect the rural environment from adverse atmospheric acidity. It is only through a properly functioning network of precipitation sampling stations for pH determinations that this protection will be insured. At the present time, only limited atmospheric pH data has been obtained by the North Dakota State Department of Health. Table 21 presents the available raw data obtained during 1977 at seven locations in western North Dakota. Table 22 presents a statistical analysis of site-specific rain data collected by the North Dakota State Department of Health. The time range in which the data was collected, the summation of samples, and the maximum and minimum pH values are presented in the table. In addition, the means and the standard deviations are given.

The results of the pH data given in Table 22 indicate a pH average of 6.0 for all sites, with individual site averages being within plus or minus 0.2 pH units of this average value. This compares with the average eastern United States precipitation pH range of 4.07 to 5.0 noted in the 1972-73 isopleths (see Map 6). The maximum pH reading measured was 8.2, the minimum pH reading was 4.4; both collected at the Bismarck site. This probably occurred because the site had the highest number of precipitation events measured. The data presented here can only be used as an indication of rain acidity. Much more data collected over a longer period of time is needed.

In Table 21, the pH or precipitation at three sites, Bismarck, west of Mandan, and Halliday, measured individual pH values in the range of pH 4.4 to 4.9, although the overall averages for these sites were comparable to the other four sampling sites. These relatively low pH, individual events, are not as acid as the Ithaca, New York,

TABLE 21

ACID PRECIPITATION EVENTS AT SEVEN COLLECTION SITES IN WESTERN NORTH DAKOTA, 1977

Collection Location	Date Collected	pH
Bismarck	3-30-77	6.6
	5-3-77	7.2
	5-4-77	6.3
	5-16-77	6.6
	5-17-77	6.2
	5-23-77	6.2
	5-25-77	8.2
	5-27-77	7.0
	5-29-77	6.7
	5-31-77	6.2
	6-3-77	5.9
	6-9-77	7.0
	6-13-77	5.5
	6-14-77	5.4
	6-17-77	5.4
	6-21-77	6.0
	6-21-77	4.7,4.5,4.4
	6-22-77	5.8
	----	6.7
	7-5-77	5.8
	7-7-77	5.9
	7-11-77	5.2
	7-27-77	6.4
	8-5-77	5.4
	8-15-77	6.1
	8-25-77	6.2
	8-27-77	5.8
	8-30-77	5.7
	9-1-77	5.9
	9-7-77	6.3
	9-8-77	5.4
	9-8-77	6.2
	9-20-77	5.7
	9-22-77	6.4
	9-23-77	5.6
	9-24-77	6.2
	9-30-77	6.1
West of Mandan	5-4-77	6.3
	5-17-77	5.6
	5-25-77	5.8
	5-29-77	6.5
	5-29-77	6.4
	6-3-77	5.7
	6-11-77	5.1
	6-14-77	4.6
	7-11-77	6.1
	8-27-77	5.3
	8-31-77	6.2
	9-2-77	5.5
	9-17-77	6.1
	9-24-77	5.8
New England	8-22-77	5.7
	8-23-77	5.6
	8-26-77	5.6
	8-30-77	5.4
	8-31-77	5.9
	9-1-77	6.4
	9-18-77	6.3
	9-20-77	6.4
	9-23-77	6.1
	9-29-77	5.3
	9-30-77	5.6
	10-1-77	5.6
Halliday	7-16-77	5.2
	8-15-77	6.4
	8-23-77	5.3
	8-26-77	6.2
	8-29-77	7.8
	8-31-77	5.7
	9-2-77	5.3
	9-9-77	6.6
	9-19-77	6.8
	9-22-77	5.6
	9-24-77	4.9
	9-30-77	5.7
Lake Tschida	9-18-77	5.6
	9-22-77	6.0
	9-24-77	6.5
	9-30-77	5.9
	10-1-77	6.4
Grassy Butte	5-18-77	6.3
	8-28-77	6.6
	9-21-77	5.8
	9-30-77	6.1
Mandaree	7-17-77	6.5
	7-28-77	5.9
	8-5-77	6.1
	8-29-77	6.0

SOURCE: North Dakota State Department of Health 1977

TABLE 22

RAINFALL pH ANALYSIS BY SITE LOCATION (1977)

Site Location	Date Range	pH
Bismarck	3-30/9-30	
Total (Σ)		234.8
Max (X_{max})		8.2
Min (X_{min})		4.4
Mean ($\overline{X}$)		6.0
No. of Samples (n)		39
Standard Deviation (σ)		0.73
Grassy Butte	5-18/9-30	
Total (Σ)		24.8
Max (X_{max})		6.6
Min (X_{min})		5.8
Mean ($\overline{X}$)		6.2
No. of Samples (n)		4
Standard Deviation (σ)		0.34
Mandaree	7-17/9-30	
Total (Σ)		24.5
Max (X_{max})		6.5
Min (X_{min})		5.9
Mean ($\overline{X}$)		6.1
No. of Samples (n)		4
Standard Deviation (σ)		0.26
Halliday	7-17/9-30	
Total (Σ)		71.5
Max (X_{max})		7.8
Min (X_{min})		5.2
Mean ($\overline{X}$)		6.0
No. of Samples (n)		12
Standard Deviation (σ)		0.83
New England	8-23/10-1	
Total (Σ)		69.9
Max (X_{max})		6.4
Min (X_{min})		5.3
Mean ($\overline{X}$)		5.8
No. of Samples (n)		12
Standard Deviation (σ)		0.39
Mandan	6-21/9-24	
Total (Σ)		86.4
Max (X_{max})		6.5
Min (X_{min})		4.6
Mean ($\overline{X}$)		5.8
No. of Samples (n)		15
Standard Deviation (σ)		0.53
Lake Tschida	9-18/10-1	
Total (Σ)		30.4
Max (X_{max})		6.5
Min (X_{min})		5.6
Mean ($\overline{X}$)		6.1
No. of Samples (n)		5
Standard Deviation (σ)		0.37

SOURCE: North Dakota State Department of Health 1977

and other examples mentioned earlier. Attempts by the Department to find a plausible explanation of these events through examination of meteorological data and pollutant emissions from nearby sources was inconclusive. It is plausible that sulfur dioxide emissions were entrained into precipitation producing weather events during the three cases. It is, however, highly unlikely that the ambient air concentrations of sulfur dioxide were of magnitudes sufficient to have caused the lower pH levels of the three rain cases.

Normally, atmospheric moisture in equilibrium with atmospheric carbon dioxide will have a pH of 5.7 (Barret, E. and G. Brodin 1975). The average value of pH 6.0 found at the seven sampling sites indicates less acidity than would normally be expected. The data agrees with studies of pH of atmospheric rainfall in Iowa (Tabatabai, M.A. and J.M. Laflen 1976) and a low population, low industrial development area of Michigan's upper peninsula (Richardson, C.J. and G.E. Merva 1976; Semonian, R.G. 1976).

In view of the preceding discussion, it would appear that the potential for acid rainfall in North Dakota is low. Even with the addition of Level 1 and Level 2 Beulah projects, the expected combined emissions of oxides of sulfur and nitrogen should not result in average annual precipitation pH values much less than that currently seen. Monitoring of precipitation pH should, however, be increased to confirm this prediction, provide a baseline for possible future coal development in the state, and to monitor the regional influence of sulfur oxides and nitrogen oxides. The monitoring of precipitation pH is indicated because of the importance of precipitation to the state's agricultural economy and general environment.

Trace Element Effects

There is currently no known pollutant present in the ambient air of North Dakota that is causing an observable effect upon human health, vegetation, or animal health. This statement is based upon analysis of effects of major pollutants; i.e., those which are found in the greatest concentration in the ambient air, which are emitted in the greatest concentration from sources such as the Level 1 and Level 2 projects, or which historically have been shown to cause problems.

In addition to these major pollutants, there are groups of other chemical elements and compounds in the environment which become involved with, and are directly or indirectly related to healthy growth and maintenance of humans, vegetation, and animals. Included are chemical groups such as fertilizers, insecticides, herbicides, fungicides, and trace elements, to name a few. These chemical groups can, and do, serve a useful purpose in agriculture, which is North Dakota's major industry. Without these chemical assists, the agricultural economy of North Dakota would not be as productive. If these chemicals are not added in excess concentrations to the environment, or are not enriched in concentration through the biological food chain, benefits can be seen. Conversely, if the concentrations are excessive in the environment, adverse effects can result in one or more of the human, vegetation, or animal receptors (animals as used in this discussion includes aquatic life and wildlife as well as domestic livestock). Although these groups of chemicals are involved in the environment, the focus of this discussion will be the trace element group.

Trace elements are found generally throughout the natural environment and, although there have been instances of high natural concentrations of these chemicals causing

problems, the greatest concern over trace elements has been with respect to man-made enrichment of chemical elements in the soil environment, with subsequent possible effects upon either vegetation or animals, or both. These effects could be either direct or via the food chain. The use of fertilizer, whether chemical or organic, will not be considered in ths discussion, although both forms contain trace elements. This discussion will be directed to the trace elements added to the air environment from energy conversion facilities and subsequently deposited on the soil.

The need for gathering and evaluating information concerning trace elements from industrial processes became a concern of the North Dakota State Department of Health in the late 1960s. The concern was fostered through the discovery of a molybdenosis toxicity condition in cattle grazing in an area influenced by the emissions of a uraniferous lignite ashing plant in the southwest corner of the state. This situation occurred before North Dakota had an air pollution law to prevent problems like this.

In 1975, initial funding to study the possible hazards of trace element emissions from coal conversion facilities was obtained from the Old West Regional Commission. This study, which is presented in the Climate and Air Quality Technical Supplement to the Draft Study, was an effort to gather background trace element data and literature concerning environmental research on specific trace elements.

The first phase of the trace element study by the Department is complete. The second phase, examining the long-term, i.e., 30 to 40 year period, is currently in process. A third phase to study of the influence of trace elements in the aquatic environment is proposed for

initiation in late 1979. All of this research work is a continuing process involving the same study area, and as each phase is completed it broadens the knowledge base on each succeeding phase.

The initial research effort allowed for the collection of a considerable body of information, but did not allow for the evaluation of the total trace element issue because of the complexities involved and the expense of performing trace element research. This study was performed in a 2,400 square mile area of western North Dakota to evaluate the potential significnce of 14 trace elements (arsenic, beryllium, cadmium, chromium, copper, fluorine, lead, mercury, molybdenum, nickel, selenium, uranium, canadium, and zinc) released to the environment through the energy conversion of coal. Sulfur was also considered, although not a trace element.

The methodology for evaluating these trace elements included the analysis of coal from four coal mines; the study of operating histories and design parameters of six lignite-fired electrical generating facilities; and the analysis of soil taken from 205 locations within the study area.

The concentrations of trace elements in the coal and the facility design parameters served as input data for a computer dispersion model with a deposition function for estimating the dry deposition of trace elements to the study area. Trace element deposition was compared to existing soil concentrations. The application of a computer dispersion and deposition model demonstrated that contemporary energy conversion facilities contribute three orders of magnitude less surface deposition than do energy conversion facilities designed and operated since the 1920s.

This report presented a methodology for determining the significance of individual trace elements released to the environment through the energy conversion of coal. For short-term (annual) projections, the projected depositions on environmental receptors are not expected to cause adverse effects on ecosystems. However, equating the potential long-term environmental significance of the quantities of these trace elements deposited in the environment, remains for further evaluation as part of this continuing research effort under Phase 2 being conducted in cooperation with the Old West Regional Commission.

The first phase study emphasized the short-term (annual) effects on the ecosystem. However, in the course of examination of trace elements from various coal-fired power plants in the study area, an interesting comparison of two facility designs developed concerning long-term effects. This comparison is shown in Table 23. Both of these plants are North Dakota electrical generating facilities with the "historic" design ceasing operation in 1968 after about 48 years of operation.

This comparison is interesting in that the "historic" plant had a projected factor of one thousand times more soil deposition per year per megawatt generation than that from the contemporary plant designed in the 1960s. This striking comparison was due to an increased thermal efficiency (burns less coal for same generating capacity), pollution control devices, and better pollutant dispersion characteristics of the contemporary facility. The facility designs of the Level 1 and Level 2 projects incorporate additional refinements beyond that of the contemporary design shown in Table 23. The "historic" facility was located at Washburn and it operated for about 48 years without apparent adverse effects due to trace element emissions in that area.

This report presented a methodology for determining the distribution of individual trace elements released to the environment through the energy conversion of coal. For short-term temporal perspectives, the projected depositions on environmental resources are not expected to cause adverse effects on ecosystems. However, equating the potential long-term environmental significance of the quantities of these trace elements deposited in the environment, requires for further evaluation as part of this continuing research effort under Phase 2 being conducted in cooperation with the Old West Regional Commission.

The first phase study emphasized the short-term, "immediate" effects on the ecosystem. However, on the degree of penetration of trace elements into various coal-fired power plants in the study area, an interesting comparison of two facility designs developed concerning long-term effects. This comparison is shown in Table 31. Both of these plants are steam turbine electrical generating facilities with the "Historic" design ceasing operation in 1974 after about 40 years of operation.

This comparison is interesting in that the "Historic" plant had a projected ratio of one thousand times more coal combusted per year per megawatt generation than that from the contemporary plant designed in the 1970s. This striking comparison was due to an increased thermal efficiency (more heat rate, for same generating capacity), pollution control devices, and better pollutant dispersion characteristics of the contemporary facility. The facility designs of the Level 1 and Level 2 projects incorporate additional technological improvements of the contemporary design shown in Table 31. The "Historic" facility was located at Hanover and it operated for about 40 years without apparent adverse effects due to trace element emissions in that area.

TABLE 23

A RELATIVE COMPARISON OF TWO FACILITY DESIGNS

DESIGN	HISTORIC[1] DESIGN	CONTEMPORARY[2] DESIGN	APPROXIMATE DIFFERENCE
Stack height	low	high	factor of two
Coal feed rate	low	high	factor of fifteen
Emissions control	no	yes	
Power generation	low	high	factor of twenty
Point of maximum deposition	less than 5 kilometers from the stack	more than 10 kilometers from the stack	
Maximum annual deposition of trace elements	very high	low	factor of fifty
Maximum annual deposition of trace elements per unit of power generation	very high	low	factor of one thousand

SOURCE: North Dakota State Department of Health - Trace Element Effects of Energy Conversion Facilities - A Phase One Final Report to the Old West Regional Commission, 1977.

[1] Approximate design period 1920

[2] Approximate design period 1960

The comparison shown in Table 23 could indicate that there will be no adverse trace element effects in the environment within ten kilometers of the Level 1 and Level 2 Beulah projects as long as the total generating capacity was under one thousand times the Washburn facility capacity of 15 megawatts or 15,000 megawatts. This analogy would indicate that the Level 1 and Level 2 power plants (1760 megawatts combined total) could operate in the Beulah vicinity without adverse effect throughout the expected lifetime of those facilities. The question of trace element deposition can be approached from another avenue, that is determining the years it would take to attain the same deposition from the 15 megawatt facility. Using a simple mathematical relationship of one thousand times the 15 megawatt capacity of the Washburn facility, times the 48 years operating period at Washburn, divided by the 1760 megawatts; yields a value of about 400 years which is well beyond the life expectancy of the Level 1 and Level 2 power plants near Beulah.

The first trace element study phase emphasized the short-term effects (annual); however, it would appear that the long-term (through the lifetime of the projects) trace element deposition from level 1 and Level 2 projects would not result in adverse effects. The Department of Health feels that, although the probability of trace element effects from Level 1 and Level 2 projects is low, this question should not be left to chance.

The second phase of trace element study, "The Long-Term Effects of Trace Elements from Energy Conversion Facilities" is scheduled for completion in July of 1979. The results of this work will shed greater light on the rather simplistic analogies discussed above. The additional pollution control design characteristics of the Level 1 and Level 2 projects

were not considered above due to the simplistic nature of the analogies.

Although further scientific study is indicated, it would appear that the emissions of trace elements from the Level 1 and Level 2 projects (including the gasification plant) would result in little or no adverse effect upon the ecosystem in the vicinity of Beulah, which is the maximum impact area.

Radiation Impacts

It is clear that exposure to radiation can cause harm to health, including cancer, genetic damage, and birth deformities. Further, effects of radiation are cumulative with each additional exposure increasing the risk of illness. Much of the attention to radioactive emissions and subsequent health effects has been related to the evaluation of nuclear power reactors and the nuclear fuel cycle (mining, milling, fuel fabrication, fuel utilization, fuel reprocessing, and waste disposal). There have been a number of studies which have documented the health hazards of radiation, including increased risk of cancer, genetic and mutagenic damage. Testimony before Congress in consideration of the Clean Air Act Amendments of 1977 also has presented concerns over the role of radiation in increased susceptibility to the diseases of aging, including diabetes, stroke, hypertension, cardiovascular disease, and cataracts.

There are no nuclear power plants in North Dakota. Other than Minnesota, there are no nuclear power plants in the states adjacent to North Dakota. The attention of environmental radiation in North Dakota, in this discussion, will be directed to the radioactive material in coal as it relates to Level 1 and Level 2 projects. Although uranium reserves exist in North Dakota, and mining and ore upgrading

activities were conducted in the 1960s, uranium activities in this state, currently, are confined to exploration with possible future development. Uranium and other naturally occurring radionuclides are found throughout the environment and in the coal used in coal-fired energy facilities. Concern has been expressed that the utilization of western coals, including North Dakota coals, will result in increased radiation in the environment causing or contributing to increased incidence of disease. There have been reports that western coal contains 10 to 100 times more radionuclides than eastern coals. This generalization, by evaluation of Table 24, is not necessarily the case. It is proper to raise this question; however, it appears that given the amount of coal development contemplated in Level 1 and Level 2 projects, the risk of increased radiation induced disease is low. Although this risk is low, it is prudent to monitor and analyze the impacts of radiation on human and animal health, not only from coal development, but oil and gas development, terrestrial and other sources, as well.

Naturally occurring uranium, which is predominately (99.28%) composed of the isotope uranium 238, is found in various concentrations throughout the environment. Uranium 238 is the parent radioactive material which, when it goes through radioactive decay, leads to other radioactive daughter products. The uranium (radium) decay series includes the radionuclides: uranium 238, thorium 234, protactinium 234, uranium 234, thorium 230, radium 226, radon 222, polonium 218, lead 214, bismuth 214, polonium 214, lead 210, bismuth 210, polonium 210 until radioactive stability (non-radioactive) is achieved with lead 206. Further discussion of the daughter radioactive products would serve only to complicate the consideration of radiation impacts under consideration in this supplement;

TABLE 24

EMISSIONS OF RADIONUCLIDES IN PARTICULATE MATTER FROM A 1000-MWe POWER PLANT: CONCENTRATION OF URANIUM, LEAD, AND POLONIUM IN FLY ASH ASSUMED (μCi/day)

	Coal Type				
Radionuclide	Appalachia	Illinois-W. Kentucky	Powder River Basin-Wyoming	Navajo Reservation New Mexico	Kaiparowits Plateau Utah
Uranium-238	66.5	150.0	63.5	87.5	48.0
Thorium-234	13.3	30.0	12.7	17.5	9.6
Protactinium-234	13.3	30.0	12.7	17.5	9.6
Uranium-234	66.5	150.0	63.5	87.5	48.0
Thorium-230	13.3	30.0	12.7	17.5	9.6
Radium-226	13.3	30.0	12.7	17.5	9.6
Radon-222	*	*	*	*	*
Polonium-218	66.5	150.0	63.5	87.5	48.0
Lead-214	66.5	150.0	63.5	87.5	48.0
Bismuth-214	13.3	30.0	12.7	17.5	9.6
Polonium-214	13.3	30.0	12.7	17.5	9.6
Lead-210	66.5	150.0	63.5	87.5	48.0
Bismuth-210	13.3	30.0	12.7	17.5	9.6
Polonium-210	66.5	150.0	63.5	87.5	48.0
Thorium-232	7.9	9.4	11.6	27.6	7.1
Radium-228	7.9	9.4	11.6	27.6	7.1
Actinium-228	7.9	9.4	11.6	27.6	7.1
Thorium-228	7.9	9.4	11.6	27.6	7.1
Radium-224	7.9	9.4	11.6	27.6	7.1
Radon-220	*	*	*	*	*
Polonium-216	7.9	9.4	11.6	27.6	7.1
Lead-212	39.5	47.0	58.0	138.0	35.5
Bismuth-212	7.9	9.4	11.6	27.6	7.1
Polonium-212	5.1	6.0	7.4	17.7	4.5
Thallium-208	2.8	3.4	4.2	9.9	2.6
Potassium-40	30.0	47.2	10.5	33.4	11.2
Total	625	1,280	631	1,110	459

Source: U.S. Environmental Protection Agency - Potential Radioactive Pollutants Resulting from Expanded Energy Programs (EPA-600/7-77-082) August 1977.

*See Table 25

although future energy development, including uranium development, will require a more complex detailed analysis.

Not a great deal of chemical analysis work for uranium has been performed on the coal which will be used by Level 1 and Level 2 projects. Analysis of samples from four coal mines in central North Dakota by the State Department of Health yielded a concentration range of less than 0.10 to 1.4 parts per million of uranium in coal used to fire the existing power plants in the Stanton and Center areas (Miller, Christianson, Schock, and Morrison, Trace Element Effects of Energy Conversion Facilities, A Phase One Final Report to the Old West Regional Commission, November 1977). These coal uranium concentrations are contrasted to the commercial concentrations of 848 to 1,187 parts per million of uranium found in the uraniferous lignite coals. The quality of known uraniferous lignite coal in North Dakota is such that this coal would not be used as a fuel in a Level 1 or Level 2 project. The uraniferous lignites which were processed for uranium upgrading in North Dakota until 1967 had a heat value of 1,000 to 5,000 Btu's per pound and 30 to 52% moisture. The commercial deposits were found in veins ranging from 1 inch to 4 feet thick.

All of the radioactive material (e.g., uranium, thorium, and their daughter products) entering a coal burning facility will ultimately be discharged to the environment either as air emissions or as solid waste. With the exception of radon which is a gas (in the uranium-thorium series decay schemes), the radioactive material will be associated with the particulate matter resulting from coal burning. All of the Level 1 and Level 2 power plants will use either an electrostatic precipitator or fabric filter system which has a particulate removal efficiency of greater than 99%. The amount, if any, of radon removal by pollution

control devices at the coal burning facility is not currently known. It is not known, for example, if some radon is trapped in the bottom ash, if some radon becomes attached to particulate matter and subsequently captured by the particulate collectors, or if scrubbers used to remove sulfur dioxide will have any appreciable effect upon radon removal. For purposes of this discussion, the worst case, or 100% release of radon to the atmosphere, will be considered.

Another radioactive material of interest in the coal burning process is potassium 40. This radioactive material is found to occur naturally throughout the environment. It is generally assumed that potassium 40 is collected as particulate matter in the control devices of the coal burning facility. Potassium is one of the major chemical elements in coal as contrasted to uranium which is considered as a trace element. The radioactive isotope, potassium 40, is, however, only 0.0118% abundant in nature. Two non-radioactive (stable) isotopes of potassium, 39 and 41, account for over 99% of the potassium in nature and presumably in the coal.

There is presently little information on the radioactive material content of North Dakota lignite coal, other than uranium concentrations. The EPA has examined the question of radioactive emissions from coal combustion in a document entitled, "Potential Radioactive Pollutants From Expanded Energy Programs" (EPA-600/7-77-082, August 1977). Table 24 contains a projection of emissions of radioactive material from 5 coal types in microcuries per day (microcuries, a unit of radioactivity describing the rate of decay of radioactive material. One microcurie equals 3.7×10^4 nuclear transformations per second.). This projection involved a number of assumptions concerning the amount and

distribution of radioactive material in the emission of particulate matter from a 1,000 megawatt power plant employing a 99.5% particulate collection efficiency.

The example shown for the Powder River coal type corresponds most closely with the lignite coals of North Dakota. The Powder River Wyoming subbituminous coal used in this projection was 8,200 Btu/lb, 6% ash, with uranium and thorium concentrations of 0.7 and 1.9 parts per million, respectively. This compares to North Dakota lignite with 6,800 to 7,000 Btu/lb, 6.2% to 8% ash, with uranium and thorium concentrations of 0.83 and 0.77 parts per million, respectively (D.N. Baria, A Survey of Trace Elements in North Dakota Lignite and Effluent Streams from Combustion and Gasification Facilities). In contrast, the subbituminous coal from the Navajo Reservation of New Mexico, in this projection, had characteristics of 8,500 Btu/lb, 25% ash, with uranium and thorium concentrations of 1.2 and 4.8 parts per million, respectively.

Releases of radon gas (radon 222 and radon 220) from these five plants were also compared in Table 25 with the assumption that all of the radon in the coal exists the stack without any removal or capture in the pollution control devices of the combustion facility. This is a maximum, worst case condition, since some radon may be caught in the sulfur dioxide scrubbers and because radon 220 has a comparatively short radiological half life of 54.5 seconds. (Radioactive half life is the time it takes a given radioactive material to decay to half its original radioactivity.) Some radon 220 could be expected to decay to a particulate with subsequent attachment to ash particulate and be captured in the particulate pollution control device. However, to simplify this discussion, 100% of the radon is assumed to be released from the Level 1 and

TABLE 25

RELEASE OF RADON ISOTOPES FROM A 1,000-MW POWER PLANT

Coal	Radon Release (μCi/day)[1] Rn-222	Rn-220
Appalachia (bituminous)	3,140	1,870
Illinois-W. Kentucky	7,050	2,220
Powder River Wyoming (subbituminous)	2,980	2,720
Navajo Reservation, New Mexico (subbituminous)	5,000	6,500
Kaiparowits Plateau, Utah (bituminous)	2,260	1,670

Source: U.S. Environmental Protection Agency Potential Radioactive Pollutants Resulting from Expanded Energy Development (EPA-600/7-77-082) August 1977

1/ μCi/day is the abbreviation for microcuries per day.

Level 2 sources. Comparing Table 24 and 25 shows that radon radioactivity emissions are projected to be greater than all the other radioactive constituents in the coal.

Given the similar characteristic (previously described) of the Powder River subbituminous coal and North Dakota lignite coal, the projected radioactivity emissions from burning of the Powder River coal in a 1,000 megawatt power plant would approximate the burning of lignite coal in a North Dakota 880 megawatt power plant. A coal gasification plant, such as the ANG facility, would have similar particulate radioactivity; however, the radon component would probably be transferred to the product synthetic natural gas. The gas loops in a gasification plant are, for the most part, closed. The projected radioactive emissions from the burning of Powder River coal formed the basis for the assumed radioactivity in the air emissions from the Level 1 and Level 2 projects. These assumed emissions are shown in Table 26.

Translating these assumed radioactivity emissions to ambient air quality can be approached by considering radioactive particulate and radon gas separately. A relationship to the ambient air quality can be developed by using the 3,325 microcuries per day total assumed particulate emission radioactivity from Table 26. From Maps 3-1 and 3-4 in the Draft Study, the maximum annual average predicted concentration of suspended particulate increase in the ambient air in the seven county study area is approximately one microgram per cubic meter from Level 1 and Level 2 sources, exclusive of the mines associated with these projects. Mine emissions will be considered later. The use of one microgram per cubic meter, due to particulate emissions, is conservative for analysis purposes since the North Dakota State Department of Health has predicted the maximum annual

TABLE 26

ASSUMED RADIOACTIVITY IN AIR EMISSIONS OF LEVEL 1 AND 2 LEVEL PROJECTS

Project	Assumed Radioactivity(μCi/day)[1/]		
	Particulate	Radon 222	Radon 220
Antelope Valley 1 and 2	631	2,980	2,720
Coyote 1 and 2	631	2,980	2,720
ANG Coal Gasification	631	-	-
NGPL Coal Gasification	1,432[2/]	-	-

Source: North Dakota State Department of Health 1978.

[1/] μCi/day is the radioactivity release per day with the units microcuries per day.

[2/] The assumption for Natural Gas Pipeline Company. (NGPL) is based upon preliminary project design information supplied by the NGPL whereas, particulate emission information for the American Natural Gas (ANG) facility was based upon actual project design.

average estimated total suspended particulate ground level concentration to be 0.4 micrograms per cubic meter from Coal Creek, Coyote 1, ANG Gasification Plant, and Antelope Valley Units 1 and 2, combined (Air Quality Effects Analysis of Basin Electric Powr Cooperative Antelope Valley Station for Air Pollution Control Permit to Construct, North Dakota State Department of Health, January 1978).

To simplify calculations, the total particulate emissions from these sources, 7,075 tons per year (from Tables 3-1 and 3-20 of the Draft Study) is based upon a 365 day year, or an average emission of 19.4 tons per day. An average emision rate of 19.4 tons per day (1.76×10^{13} micrograms per day) results in an annual ambient average increase of 1-2 micrograms per cubic meter. The one microgram per cubic meter value will be used as the average concentration expected to occur over a 24-hour averaging period. During this average 24-hour period, 1.76×10^{13} microgram of particulate is released to the ambient air. To further simplify the analysis, the impact of one microgram per cubic meter annual average is, for the most part, from Map 3-4 of the Draft Study confined to Mercer and Oliver Counties with a narrow band of one microgram per cubic meter extended westward into central Dunn County. A dispersion factor, translating the emission quantity per day to average ambient air quality increase, is one microgram per cubic meter divided by 1.76×10^{13} micrograms per day or $5.68 \times 10^{-14} m^{-3}$ day.

This dispersion factor times the total assumed particulate radioactivity of 3,325 microcuries per day, yields an expected average particulate radioactivity in the ambient air of 1.89×10^{-10} microcuries per cubic meter or 189 attocuries (10^{-18} curies) per cubic meter average daily concentration.

Very little ambient air quality data exists in the United States today concerning radioactivity from the radioactive materials listed in Table 24. This is due to the expense and complexities involved in analyzing samples with low levels of radioactivity. In North Dakota and other areas of the United States, there is a considerable amount of beta radiation data, but the data is gross and not quantitative. In a recent document entitled "Radiological Quality of the Environment" (EPA-520/1-76-010 May 1976), EPA reported the analysis results of air samples collected at Bismarck by the North Dakota State Department of Health from July 1974 through June 1975. These results are summarized in Table 27.

Although the radioactivity across the state can be expected to vary, the Bismarck data will be used as an indicator of airborne uranium 234, 235, and 238 radioactivity for the study area for lack of more geographical specific data. Bismarck results from Table 27 compare favorably with the network summaries, particulately in the maximum values noted.

Uranium 234 and 238 are shown in the list of radionuclides of Table 24; however, uranium 235 is not. The radioactivity, due to uranium 34 and 238, is shown in Table 24 to account for approximately 20% of the total radioactivity in the Powder River Basin coal type. The total average radioactivity of uranium 234 and 238 at the Bismack sampling site is shown in Table 27 to be 106.8 microcuries per cubic meter. If one assumes the same radionuclide equilibrium conditions as found in Table 24, the total particulate radioactivity at the Bismarck sampling site could be 534 microcuries per cubic meter. This value, when compared to the projectd 189 microcuries per cubic meter ambient air quality increase in radioactivity, would indicate an

TABLE 27

AIRBORNE RADIOACTIVITY DUE TO URANIUM 234, URANIUM 235 AND URANIUM 238 AT BISMARCK DURING THE PERIOD JULY 1974 TO JULY 1975

Uranium Isotope	Samples Analyzed[1]	Attocuries[2] per cubic meter	
		Maximum	Average
Uranium 234			
Bismarck	4	65.4	54.8
Network Summary[3]	65	1290	82.1
Uranium 235			
Bismarck	4	4.1	3.6
Network Summary[3]	65	54.3	4.49
Uranium 238			
Bismarck	4	62.2	52.0
Network Summary[3]	65	232	52.7

Source: Compiled from the U.S. Environmental Protection Agency - Radiological Quality of the Environment (EPA-520/1-76-010) 1976.

[1] Uranium analyses were performed on quarterly composite samples of air filters collected at 19 airborne particulate sampling sites across the United States. Above uranium isotopes were determined by alpha spectroscopy following chemical treatment of the samples. The volume of air sampled ranged between 25,000 and 40,000 cubic meters for each quarterly composite sample analyzed.

[2] Attocuries is a unit of radioactivity 10^{-18} curies.

[3] The locations used in determination of the network summary were Montgomery, AL; Berkeley and Los Angeles, CA; Denver, CO;Miami, FL; Idaho Falls, ID; Bismarck, ND; Santa Fe, NM; Las Vegas, NV; Buffalo and New York City, NY; Columbus, OH; Oklahoma City, OK; Portland, OR; Harrisburg and Pittsburg, PA; Anderson and Columbia, SC; and Lynchburg, VA.

increase of approximately 35%. Relating this increase to perceptible increase in the incidence of human and animal disease in the study area, assuming the Bismarck data represents the study area, is impossible at this time. The radiation risk of particulate radioactivity cannot be assessed without further study and actual data.

Analysis of the increase in ambient radon gas radioactivity from the Level 1 and Level 2 projects can follow the same approach as used in the analysis of particulate radioactivity; however, it is assumed that 100% of the radon in the coal is released from the Level 1 and Level 2 coal fired power plants. This is a conservative assumption, because it does not take into account the possibility of radon capture in the source prior to release or the relatively short radioactive half life of radon 220. Referring again to Table 26, the total projected radon 222 release from the Level 1 and Level 2 projects is assumed to be 5.960 microcuries per day into the seven county study area.

The average natural release of radon 220 above soil has been estimated at 150 microcuries per acre per day (U.S. Environmental Protection Agency, Potential Radioactive Pollutants Resulting From Expanded Energy Programs, EPA-600/7-77-082, August 1977). Given the area of 6,835,840 acres from Table 28 in the seven county study area, the radon 220 release from the soil in the entire region would be $1.03\text{x}10^9$ microcuries per day or a factor of about 180,000 times that from the Level 1 and Level 2 power plants. The use of the entire seven county area has a tendency to over magnify the difference between the radon emission from the power plants and that from the natural radon 222 release from the soil.

TABLE 28

SURFACE AREA OF SEVEN-COUNTY STUDY AREA, BY COUNTY

County	Area[1] (Square Miles)	Area (Acres)
Burleigh	1,625	1,040,000
Morton	1,920	1,228,800
Stark	1,316	842,240
Dunn	1,992	1,274,880
McLean	2,065	1,321,600
Mercer	1,042	666,880
Oliver	721	441,440
Totals	10,681	6,835,840

Source: North Dakota State Department of Health

[1] Obtained from "County and City Data Book - 1967" U.S. Department of Commerce.

It is more realistic to use the counties in which the Level 1 and Level 2 impacts would be the greatest; i.e., Mercer and Oliver Counties. From Table 28, the total surface area for Mercer and Oliver Counties is 1,108,320 acres or a projected radon 222 release in those counties of 166×10^6 microcuries per day from the soil. This radon 222 soil release is about 28,000 times that from the Level 1 and Level 2 stack emissions.

Examining the radon 222 emissions from the power plant stacks and assuming that all of the radon gas is uniformly delivered at ground level within these two counties results in an insignificant 0.0054 microcuries per acre per day increase when compared to the natural radon 222 release of 150 microcuries per acre per day from the soil.

Natural radon release from soil in North Dakota is not currently known. The influences of factors such as soil moisture content, frozen soil, and the intensity of agricultural activities, specific to North Dakota, have not been determined. These factors could alter the 150 microcuries per acre per day natural radon release rate used in the preceding analysis. Although the probability of increased health risk to humans and animals from radon gas releases from Level 1 and Level 2 projects appears to be low, further study of the natural release of radon gas from the soil appears warranted.

Increases in particulate radioactivity would result from mining activities associated with the Level 1 and Level 2 projects; however, from Figure 3-1 of the Draft Study, the increase in suspended particulate matter and, subsequently, the particulate radioactivity would be small compared to the suspended particulate and naturally occurring radioactive particulate uranium, thorium and daughters from unpaved

roads and agricultural activities. Additional terrestrial radiation analyses are needed concerning the radiation risks to health of humans and animals, especially concerning the radioactivity released to the environment from unpaved roads and agricultural activities which are projected to account for 91.4% or approximately 100,000 tons per year of particulate matter in four of the seven study counties. Further study may indicate that the radioactivity in the particulate matter resulting from existing unpaved roads and agricultural activities may result in a greater radiation risk to human and animal health than from the projected particulate emissions from the Level 1 and Level 2 projects, including associated mining activities.

As was discussed earlier, an assumption was used that more than 99% of the particulate radioactivity would be removed in the pollution control devices with the resulting emissions comparable to the measurements of airborne radioactivity at Bismarck, both quantities of radioactivity small; i.e., in the attocurie range of radioactivity in the ambient air. One area of possible future concern is the fate of the collected particulate radioactivity; i.e., the more than 99% that did not get away.

The EPA in "Potential Radioactive Pollutants Resulting From Expanded Energy Programs" (EPA-600/7-77-082) discussed this question. Table 29 is reproduced from this document. Factoring in the life expectancy of plant operations is appropriate because the localized storage of collected wastes accumulates with time. This accumulation includes radium 226 which is a parent to radon 222 in the uranium decay series. This radium 226 30-year accumulation results in the radon 222 releases shown in Table 29. It is important to note that the units of radioactivity in Table 29 are curies per day. The values shown in Table 29 for

TABLE 29

MAXIMUM RADON-222 RELEASE FROM 30-YEAR ASH STORAGE PILE FROM 1,000-MW POWER PLANT

Coal Type	Area of Pile (acres)	Ra-226 Content[1] (grams)	Rn-222 Release (Ci/day)[2]
Appalachia	176	26.2	4.6
Illinois-W. Kentucky	245	59.5	10.5
Powder River	179	25.4	4.5
Navajo	721	42.0	7.4
Utah	159	19.3	3.4

Source: U.S. Environmental Protection Agency - Potential Radioactive Pollutants Resulting From Expanded Energy Programs (EPA-600/7-77-082) August 1977.

[1] Ra-226 is the abbreviation for radium 226. Radium 226 is the parent radionuclide of radon 222.

[2] Ci/day is the abbreviation for the radioactivity unit curies per day. A curie is 10^6 microcuries.

Powder River coal are, therefore, approximately 1,500 times greater than the radon 222 microcurie releases shown in Table 25.

It is impossible for all of the radon in these piles to be released into the air. EPA quoted references which state that about 5% of the radon is released, assuming that the radon release from coal ash piles is similar to that from uranium mill tailings piles. These ash piles could, however, locally increase the radon 222 radioactivity by factors of 3.4 to 15 above natural background. The release of radon gas from the coal ash could be reduced by burying the ash with earth cover at the reclaimed mine site. Other factors which need to be examined in the future, as previously mentioned, are the influences of soil moisture content and frozen soil on the release of radon through and from the soil. In addition, burying the coal ash should be preceded by an analysis of the possibility of ground water contamination by leaching of radioactive elements. The use of a layer of impermeable material between the coal ash wastes and the aquifer, as well as ground water monitoring, may be necessary to limit this possible contamination.

From the preceding analysis, the radiation impacts upon human and animal health as a result of Level 1 and Level 2 projects are expected to be very low with the natural radioactivity in the region significantly higher than the projected and assumed increases from facility emissions. As stated in this analysis, a number of assumptions were made due to a lack of site specific information such as the radionuclide content of North Dakota lignite coals, existing airborne radioactivity, soil concentrations or uranium, thorium, and their daughter radionuclides, and the natural radon release from North Dakota soils. These assumptions, although believed to be conservative; i.e., magnifying the

expected impacts, should be validated by actual radiological field determinations.

Effects on Materials

Air pollution has a variety of effects on materials, including corrosion of metals, deterioration of materials and paints, and fading of dyes. The effects of air pollution on the material things around us is often the first effect to be noticed by the average citizen. This damage to property is annoying, causes inconveniences, and can cause expensive economic losses.

Materials may be damaged by any of several mechanisms, depending upon the type of material and the nature of the air pollutant, including:

1. Abraison

   Abraison is caused by a solid particle destroying the surface of the material. This is a physical erosion of the surface of the material by particulate pollutants. The particles strike the material (usually a metal or a building material) and a resultant wearing-away of the surface occurs. If abrasive particles become imbedded in fabrics, the fibers are subjected to increased wear.

2. Deposition and Removal

   Deposition is a depositing of a particle (liquid or solid) on the surface of the material. Basically, this is soiling.

   Soiling may or may not be harmful to the property, depending upon the nature of the deposited pollutant. It is usually desirable, however, to remove the

collected soil, and in the cleaning process slight damage is done to the material.

An example is the soiling of a stone building. For aesthetic reasons, the building must be cleaned, and sandblasting is the usual way of accomplishing this. The blasting removes the soil, but with it a small amount of the stone surface is removed.

Deposition, then, is soiling by a particulate pollutant, either solid or liquid. This deposited matter usually must be removed, and the removal is often more deleterious than the soiling itself.

3. Chemical Attack

Chemical attack by gaseous or particulate pollutants affects virtually all materials. A true chemical reaction occurs between the pollutant and the material itself.

An example of chemical attack is the damage to building stone by carbon dioxide. The stone normally is composed of insoluble calcium carbonate. In the presence of water and carbon dioxide, carbonic acid is formed, and this acid will react with the calcium carbonate to form a soluble bicarbonate. The surface of the stone can then be dissolved in water present in the air or in rain.

Many other instances of chemical attack can be cited; the tarnishing of silver by hydrogen sulfide, the reaction of sulfur dioxide with metals, and the darkening of lead-base paints by hydrogen sulfide.

Certain chemical attacks occur in a less direct manner. Sulfur dioxide, for example, is adsorbed on leather in a dry atmosphere with little or no damage to the leather. But when water is present, the adsorbed sulfur dioxide is converted to sulfuric acid, and the leather is attacked.

4. Electrochemical Corrosion

Much of the attack on materials exposed to the atmosphere is by electrochemical corrosion. Many small electrochemical cells form on the exposed surface.

Electrochemical corrosion of metals is caused by gaseous or particulate pollutants in the presence of atmospheric moisture. If the metal is clean and dry, no current will flow and no corrosion will occur. If water is present, some corrosion will occur, but the rate of corrosion is greatly increased if the water is contaminated with pollutants.

Table 30 briefly summarizes the various mechanisms of attack, the type pollutant responsible, and the type material affected. Few materials escape attack by atmospheric pollutants. Some of the materials affected, and the type of damage incurred, are as follows:

1. Metals

Metals are subject to electrochemical corrosion, to other chemical attack by gaseous or particulate pollutants (e.g., tarnish, rust), and to abrasion by wind-blown particles.

TABLE 30

SUMMARY OF MECHANISMS OF ATTACK

Mechanism	Type of Pollutant	Materials Affected
Abrasion	solid	metals, fabrics, building materials
Deposition and Removal	solid or liquid	metals, paints, fabrics, building materials
Chemical Attack	gas, liquid or solid	metals, paints, building materials, fabrics, dyes, paper leather
Electrochemical Corrosion	gas, liquid or solid	metals

Several studies have been undertaken to show that metals deteriorate much more rapidly in polluted atmospheres than in clean air. Field research has proven that steel, zinc, copper, nickel, lead, and tin all show a greater degree of corrosion in urban-industrial areas than in rural locations. One study showed that steel samples exposed in urban atmospheres corroded at 30 times the rate of similar samples exposed in rural areas.

This effect on metals is especially troublesome to those involved in electrical industries. Contacts must be inititally larger and must be wiped often to counteract the corrosion film which acts as an insulator. This is of critical concern to communications and power companies.

2. Protective Coatings

Paints and protective coatings serve two purposes: to protect a surface and to beautify that surface. When the protective film is damaged by gaseous or particulate pollutants, the beauty of the surface is destroyed, and the underlying surface is exposed to attack. Often the tarry matter in soot tends to incorporate in paint layers, and this material cannot be removed without ruining the surface.

Hydrogen sulfide becomes a problem where lead-base paints are in use. The chemical reacts with the paint to form the blackish lead sulfide. The exposed painted surfaces acquire a slotchy, heavily stained appearance which varies in color from a grayish-brown to black. It is true that the darkened paint will eventually be oxidized in clean air to a white form, but this can be

a lengthy procedure. Usually it will be necessary to repaint the building.

3. Fabrics

Fabrics are affected by air pollution, usually by soiling. City dwellers notice that clothing and draperies must be cleaned much more frequently than those of their rural counterparts. In addition to the necessity for increased cleaning which causes excessive wear, the fabrics are actually damaged if abrasive particles are allowed to remain imbedded in the fibers.

Fabrics may also be attacked chemically. This has been illustrated in the larger metropolitan areas of the country. Girls on the way to work in the downtown areas found that their nylon stockings were popping and running for no apparent reason. The cause was traced to pollution of the atmosphere with minute windborne particles of sulfuric acid. When a particle landed on a nylon thread, a run began. Instances of less delicate fabrics being attacked in a similar manner have been reported.

4. Dyes on Fabrics

Dyes on fabrics are subject to fading and discoloration in polluted air. For example, a blue dye might fade to a lighter blue color, or it might discolor to a reddish tone. Certain dyes are most susceptible than others, and extensive testing has been done by fabric manufacturers to determine the color-fastness of various dyes which are developed.

Oxides of nitrogen and ozone are contaminants which have been shown to affect dyes. Sulfur dioxide is the source of adsorbed acid which can accelerate the reactions.

It should be stressed, however, that certain dyes will fade in sunlight, even in the absence of any contaminating substances.

5. Rubber

One of the first-noted effects of the Los Angeles smog episodes was the cracking of rubber tires. The damage was traced to oxidation by ozone and other oxidants present in the smog. Since that time, much research has been done to establish the effect of ozone on natural rubber and on various types of synthetic rubber.

It is thought that ozone attacks the double bond of the unsaturated rubber formulations, such as butadiene-styrene and butadiene-acrylonitrile. These are susceptible to attack while the unsaturated ones, such as butyl and silicone rubber, are not harmed.

The effect of ozone on rubber is so predictable that it has been used as the basis for a method of ozone detection.

6. Building Materials

Probably one of the most readily noticed effects on building materials is the soiling so familiar to city dwellers. Soiling is a gradual process and often attracts little attention until a cleaning is under-

taken, and the contrast between the clean and soiled portions is startling. In many cases, the color of the stone and architectural details are obscured under the layers of grime.

While soiling is displeasing, more serious damage to building materials may be done by certain acidic gases in the air, such as carbon dioxide. The carbon dioxide, in the presence of water, forms an acid, and this acid tends to dissolve the stone.

Abrasive particles, blown about by the wind, might also erode the exposed surfaces of building materials.

7. Paper

If paper is exposed to atmospheric sulfur dioxide, the paper becomes brittle and cannot be folded without cracking. Many important documents could potentially be lost in this way. Valuable historical documents must be stored and displayed in specially-maintained atmospheres.

This effect, however, only applies to relatively "modern" papers, those manufactured since about 1750, when chemical methods of paper manufacture were introduced. Traces of heavy metals remain in the papers and these impurities cause acceleration of the damage.

8. Leather

Leather is another material which becomes embrittled in the presence of sulfur dioxide. This effect was noted by Faraday in the 1840s. The leather armchairs in his club were cracking in the polluted London air.

This problem affects such diversified articles as the leather-upholstered furniture mentioned above, valuable bookbindings and even such things as the leather bellows in large church organs.

It is safe to say that most of the materials upon which we depend for everyday use can in some way be adversely affected by pollution in the air.

A certain amount of deterioration will occur even in unpolluted air. There are several factors to consider in determining the amount of deterioration that is caused by a particular pollutant, including:

1. Concentration of the Pollutant

   The concentration of the pollutant in the air is important to consider. In general, the degree of deterioration will be roughly proportional to the amount of pollutant present.

2. Moisture

   Moisture is probably the most critical influencing factor. Below a certain relative humidity, very little deterioration occurs. Some water must be present for metals to rust or corrode. Acidic gases cause their damage only in the presence of water (see Table 31).

   On the other hand, a great amount of moisture (a rain storm, for example) may tend to wash away the pollutants and lessen the damage.

TABLE 31

CORROSION OF METALS IN AIR

Relative Humidity	Degree of Corrosion
<60%	none
>60%	slow but definite
80%	decided increase
>80%	very high

SOURCE: W. H. J. Vernon, Chemistry and Industry, Jubilee Memorial Lecture (1943)

3. Temperature

A change in temperature has an important effect on the amount of deterioration. Generally, the rate of a chemical reaction increases with an increase in temperature.

If a drop in temperature occurs, certain vaporous pollutants may condense on the surface of materials, and thus have an opportunity to react.

4. Sunlight

It is well known that sunlight itself may have undesirable effects on certain materials; e.g., sunlight causes the fading of some dyes. It may have a more indirect effect by accelerating certain reactions which lead to deterioration. Also, new pollutants may be formed under the influence of sunlight (for example, smog) and the new pollutant may have a harmful effect on certain materials.

5. Air Movement

Wind speed and wind direction are critical factors, especially in the case of erosion by particulate matter. The particles must strike the surface at such an angle and with sufficient velocity for deterioration to occur.

Also, if the wind speed is high enough to cause dispersion of the pollutants, the effect will be greatly reduced.

Probably the chief way in which atmospheric deterioration of materials affects us is as an economic loss. The various costs caused by air pollution include the following:

1. Cleaning Costs

   Excess cleaning due to dirty air includes the increased need for cleaning of home and furnishings, more frequent dry cleaning and laundering of clothing, increased hair and facial care, increased car washings, increased cleaning of buildings and monuments, and increased washing of street lighting luminaries.

2. Painting Costs

   When paint has been marred or damaged by air pollutants, the surface usually needs to be repainted, both for appearance and protection.

3. Repair and Replacement Costs

   Materials damaged by air pollution must be repaired. If they are very badly damaged, they may have to be completely replaced.

4. Over-Design

   One of the more subtle costs of air pollution is that of over-design. Larger electrical contact points must be used so that insulating pollutant films do not form so rapidly. Entire systems must be completely enclosed in a protective capsule. Extra air-purifying devices must be installed in various operations. More inert (and thus more expensive) metals must replace such

things as silver in electrical contacts. All these "hidden costs" are reflected in the cost to the consumer.

5. Reduced Property Values

No one prefers to live and work in unpleasant, polluted surroundings. Dirty air can have a real effect on and lower the value of property.

The Federal Housing Administration considers homes in polluted areas as a poor risk, and often refuses mortgages on these grounds.

The effects of specific pollutants and which materials each affects are as follows:

1. Particulates

Particulate air pollution causes a wide range of damage to materials. Particulate matter may attack materials by abrasion or may chemically attack materials through its own intrinsic corrosiveness, or through the corrosiveness of substances absorbed or adsorbed on it. Merely by soiling materials, and thereby causing their more frequent cleaning, particulates can accelerate deterioration.

Laboratory and field studies underscore the importance of the combination of particulate matter and corrosive gases in the deterioration of materials. On the basis of present knowledge, it is difficult to evaluate precisely the relative contribution of each of the two classes of pollution; however, some general conclusions may be drawn.

Particulates play a role in the corrosion of metals. In laboratory studies, steel test panels, that were dusted with a number of active hygroscopic particles commonly found in the atmosphere, corroded even in clean air. Corrosion rates were low below a relative humidity of 70%; they increased at relative humidities above 70%; and they greatly increased when traces of sulfur dioxide were added to the laboratory air.

It is apparent that the acceleratd corrosion rates of various metals in urban and industrial atmospheres are largely the result of relatively higher levels of particulate pollution and sulfur oxides pollution. High humidity and temperature also play an important synergistic part in this corrosion reaction. Studies show increased corrosion rates in industrial areas where air pollution levels, including sulfur oxides and particulates, are higher. Further, corrosion rates are higher during the fall and winter seasons when particulate and sulfur oxides pollution is more severe.

Particulate air pollution damages electrical equipment of all kinds. Oily or tarry particles, commonly found in urban and industrial areas, contribute to the corrosion and failure of electrical contacts and connectors. Dust can interfere with contact closure and can abrade contact surface. Hygroscopic dusts will absorb water and form thin electrolytic films which are corrosive.

Particulates can soil and damage buildings, statues, and other surfaces. The effects are especially severe in urban areas where large quantities of coal and sulfur-bearing fuel oils are burned. Particles may act as reservoirs of acids, and thereby sustain a chemical

attack that will deteriorate even the more resistant kinds of masonry. Particles stick to surfaces, forming a film of tarry soot and grit which often times is not washed away by rain. Considerable money and effort have been spent in many cities to sandblast the sooty layers that accumulate on buildings. Water-soluble salts, commonly found in urban atmospheres, can blister paint. Other particles may settle on newly painted surfaces, causing imperfections, thereby increasing the frequency with which a surface must be painted.

The soiling of textiles by the deposition of dust and soot on fabric fibers not only makes them unattractive, and thereby diminishes their use, but results in abrasive wear of the fabric when it is cleaned. Vegetable fibers, such as cotton and linen, and synthetic nylons are particulary susceptible to chemical attack by acid components of airborne particles.

The Environmental Protection Agency, after a careful evaluation of American and foreign studies, concluded that corrosion of steel and zinc panels occurs at an accelerated rate when particulate concentrations ranging from 60 micrograms per cubic meter (annual geometric mean) to 180 micrograms per cubic meter (annual geometric mean) occur in the presence of sulfur dioxide and moisture. They set the National Secondary Ambient Air Qulity Standards for particulate matter at 60 micrograms per cubic meter annual geometric mean, and 150 micrograms per cubic meter maximum 24-hour concentration not to be exceeded more than once per year. National Secondary Ambient Air Quality Standards define levels of air quality which the Environmental Protection Agency judges necessary to protect the

public welfare from any known or anticipated adverse effects of a pollutant.

2. Sulfur Oxides

The oxides of sulfur (especially sulfur dioxide) cause increased corrosion of metals,, deterioration of building materials, weakening and embrittlement of paper and leather, and weakening or actual disintegration of certain textiles such as nylon.

Laboratory and field studies underscore the importance of the combination of particulate and sulfur oxides pollution in a wide range of damage to materials. On the basis of present knowledge, it is difficult to precisely evaluate the relative contribution of each of the two classes of pollution; however, some general conclusions may be drawn.

Steel test panels, dusted with a number of active hygroscopic particles commonly found in polluted atmospheres, corroded at a low rate in clean air at relative humidities below 70%. The corrosion rate was higher at relative humidities above 70%. It greatly increased when traces of sulfur dioxide were added to the laboratory air.

It is apparent that corrosion rates of various metals are higher in urban and industrial atmospheres with relatively high levels of both particulate and sulfur oxides than they are in rural and other areas of low pollution. High humidity and temperature also play an important synergistic part in this corrosion reaction. Studies show increased corrosion rates in industrial areas where air pollution levels, including sulfur

oxides and particulates, are higher. Further, corrosion rates are higher during the fall and winter seasons when particulate and sulfur oxides pollution is more severe. Depending on the kind of metal exposed as well as location and duration of exposure, corrosion rates were 1-1/2 to 5 times greater in polluted atmospheres than in rural environments.

In Chicago and St. Louis, where steel panels were exposed at a number of sites, high correlations were found in each city between corrosion rates, as measured by weight loss, and sulfur dioxide concentrations. In St. Louis, except for one exceptionally polluted site, corrosion losses were 30% to 80% higher than losses measured in nonurban locations. Sulfation rates in St. Louis, measured by lead peroxide candle, also correlated well with weight loss due to corrosion. Measurements of dustfall in St. Louis, however, did not correlate significantly with corrosion rates. Over a 12-month period in Chicago, the corrosion rate at the most corrosive site (mean sulfur dioxide level of 320 micrograms per cubic meter (0.12 parts per million)) was about 50% higher than at the least corrosive site (mean sulfur dioxide level of 80 micrograms per cubic meter (0.03 parts per million)). Although suspended particulate levels measured in Chicago and high-volume samplers also correlated with corrosion rates, a co-variance analysis indicated that sulfur dioxide concentrations were the dominant influence on corrosion. Based on these data, it appears that considerable corrosion may take place (i.e., from 11% to 17% weight loss in steel panels) at annual average sulfur dioxice concentrations in the range of 80 micrograms per cubic meter (0.03 parts per million) to 320 micrograms per cubic meter (0.12 parts per

million), and although high particulate levels tend to accompany high sulfur dioxide levels, the sulfur dioxide concentration appears to have the more important influence.

Sulfur oxides pollution contributes to the damage of electrical equipment of all kinds. Studies have reported a one-third reduction in the life of overhead powerline headware and guy-wires in heavily polluted areas. In some areas, it has been found necessary to use more expensive, less corrodible metals, such as gold, for electrical contacts.

Sulfur oxides pollution attacks a wide variety of building materials - limestone, marble, roofing slate, and mortar - as well as statues and other works of art, causing discoloration and deterioration. Certain textile fibers (such as cotton, rayon, and nylon) are harmed by atmospheric sulfur oxides. Dyed fabrics may fade in atmospheres containing sulfur oxides and other pollutants. Severe fading was noted for some dyes in fabrics exposed in Chicago, where annual average sulfur dioxide levels were 240 micrograms per cubic meter (0.09 parts per million). Leather exposed to sulfur oxides may lose much of its strength, and paper may become discolored and brittle.

Concentrations of 2,600 micrograms per cubic meter (1 part per million) sulfur dioxide can increase the drying time of some oil-based paints by 50 to 100%. Some films become softer and others more brittle, both developments adversely affecting durability. Sulfur dioxide also appears to render some paint films water sensitive, consequently reducing the film gloss. Under certain conditions, sulfur dioxide levels of 260

micrograms per cubic meter (0.1 part per million) to 520 micrograms per cubic meter (0.2 part per million) cause the blueing of Brunswick green, and in the presence of ammonia produce a troublesome defect called crystalline bloom brought about by the formation of very small ammonium sulfate crystals.

The Environmental Protection Agency, after careful evaluation of American and foreign studies, concluded that adverse effects on materials were observed at an annual mean of 320 micrograms per cubic meter (0.12 part per million) for sulfur dioxide. They set the National Primary Ambient Air Quality Standard at 80 micrograms per cubic meter (0.03 part per million) annual arithmetic mean and 365 micrograms per cubic meter (0.14 part per million) maximum 24-hour concentration not to be exceeded more than once per year. The National Secondary Ambient Air Quality Standardas set at 1,300 micrograms per cubic meter (0.5 part per million) maximum 3-hour concentration not to be exceeded more than once per year. These standards were set for reasons other than effects on materials.

3. Nitrogen Oxides

Significant effects of nitrogen oxides have been observed and studied on three classes of materials: textile dyes and additives, natural and synthetic textile fibers, and metals.

The most pronounced problem is associated with textile dyes and additives. Fading of sensitive disperse dyes used on cellulose acetate fibers has been attributed to nitrogen dioxide levels below 188 milligrams per cubic meter (less than 100 parts per million). Loss of

color, particularly in blue and green dyed cotton and viscose rayon, has occurred in gas dryers where nitrogen oxide concentrations range from 1.1 to 3.7 milligrams per cubic meter (0.6 to 2 parts per million). Yellow discoloration in undyed white and pastel-colored fabrics has been attributed to nitrogen oxides by controlled laboratory experiments.

Laboratory and field observations have shown that cotton and nylon textile fibers can be deteriorated by the presence of nitrogen oxides, but specific reactants and threshold levels are undetermined.

Failure of nickel-brass wire springs on relays has been related to high particulate nitrate levels. This type of stress corrosion has been observed when surface concentrations of particulate nitrates have exceeded 2.4 micrograms per cubic meter and relative humidity was greater than 50%. Another type of this corrosion has been associated with annual average particulate nitrate concentrations of 3.0 and 3.4 micrograms per cubic meter with corresponding nitrogen oxide levels of 2124 and 158 micrograms per cubic meter (0.066 and 0.084 parts per million).

The Environmental Protection Agengy, after careful evaluation of studies, concluded that although damage to materials has been attributed to nitrogen oxides in ambient atmospheres, the precise air concentrations producing these effects have not been determined. With respect to stress corrosion, they found that nitrogen oxide reaction products have been associated with corrosion and failure of electrical components at annual average particulate nitrate levels of 3.0 to 3.4 micrograms per cubic meter with associated average

nitrogen oxide levels of 124 to 158 micrograms per cubic meter (0.066 to 0.084 parts per million).

The Environmental Protection Agency has set the National Primary and Secondary Ambient Air Quality Standard for nitrogen dioxide at 100 micrograms per cubic meter (0.05 part per million) annual arithmetic mean.

4. Photochemical Oxidants

Photochemical oxidants, especially ozone, primarily affect rubber, causing embrittlement and cracking. Ozone is also known to cause fading and discoloration in certain dyed fabrics.

The detailed, quantitative extent of damage to materials caused by atmosphere levels of ozone is unknown, but generally any organic material is adversely affected by concentrated ozone. Many polymers are extremely sensitive to even very small concentrations of ozone; this sensitivity increases with the number of double bonds in the structure of the polymer.

Economically, rubber is probably the most important material sensitive to ozone attack, particularly styrene-butadiene, natural, polybutadiene, and synthetic polysioprene. Antiozonant additives have been developed and are capable of protecting elastomers from ozone degradation. Synthetic rubbers with inherent resistance to ozone are also available. These additives are expensive, however, and add to the cost of the end product. In addition, increasing amounts of antiozonants are required as the amount of ozone which

is to be encountered increases, and sometimes only temporary protection is provided.

Ozone attacks the cellulose in fabrics through both a free radical chain mechanism and an electrophilic attack on double bonds; light and humidity appear necessary for appreciable alterations to occur. The relative susceptibility of different fibers to ozone attack appears to be, in increasing order, cotton, acetate, nylon, and polyester.

Certain dyes are susceptible to fading during exposure to ozone. The rate and extent of fading is also dependent upon other environmental factors such as relative humidity and the presence of air pollutants other than ozone, as well as the length and concentration of ozone exposure and the type of material exposed.

The Environmental Protection Agency, after careful evaluation of many studies, has concluded that adverse effects on materials from exposure to photochemical oxidants have not been precisely quantified, but have been observed at the levels presently occurring in many urban atmospheres. They have set the National Primary and Secondary Ambient Air Quality Standards for photochemical oxidants at 160 microgram per cubic meter (0.08 part per million) maximum 1-hour concentration not to be exceeded more than once per year. EPA has recently proposed the National Primary Ambient Air Quality Standard for ozone to be set at 200 micrograms per cubic meter (0.10 parts per million).

5. Hydrogen Sulfide

Hydrogen sulfide has two widely observed effects: the darkening of lead-base paints and the tarnishing of certain metals such as silver. In addition, hydrogen sulfide may be oxidized to sulfur dioxide or sulfur trioxide, and these will produce characteristic effects as previously discussed.

Damage to lead-based or pigmented paints and paints containing mercury based fungicides can be caused by hydrogen sulfide. Discoloration occurs when the metallic oxides react with the hydrogen sulfide to form metallic sulfides. The occurrence of this type of damage depends considerably upon the presence of water, which hastens the reaction and allows it to occur with smaller amounts of hydrogen sulfide. When the paint surface is moistened, damage may occur with exposures of less than 1-hour and concentrations as low as 140 micrograms per cubic meter (0.1 part per million). Paint blackness, under dry conditions, occurs at concentrations of 1,400 micrograms per cubic meter (1.0 part per million) for 30 minutes exposure time. Tarnishing of silver and copper occurs slowly at concentrations as low as 4 micrograms per cubic meter (0.003 part per million).

The North Dakota State Department of Health has adopted ambient air quality standards for hydrogen sulfide of 45 milligrams per cubic meter of air (0.032 part per million), maximum 1/2 hour concentration not to be exceeded more than twice in any five consecutive days, and 75 milligrams per cubic meter of air (0.054 part per million), maximum 1/2 hour concentration not to be exceeded over twice a year. These concentrations would

be detected as odors by some people, and some tarnishing of metals would occur, but the frequency of such occurrences would be low.

6. Carbon Dioxide

Carbon dioxide is an acidic gas which causes the deterioration of building stone by formation of soluble carbonates. It is also responsible for the corrosion of certain metals such as magnesium. Carbon dioxide is normally not considered as an air pollutant, as it has no known effects on health at the levels normally encountered in the ambient air.

The projected ambient air quality changes due to pollutant emissions from the Level 1 and Level 2 projects are summarized in Table 13 for particulate matter, sulfur dioxide, and nitrogen dioxide. These projected changes are well under the concentrations known to cause observable effects on materials. Therefore, any adverse effects on materials should be small and their frequency of occurrence would be low. The effects on materials for other pollutants such as hydrogen sulfide and carbon dioxide would be very small as these pollutants would not be emitted in large quantities.

Effects on Visibility

Visibility reduction is one of the most common and dramatic effects of air pollution. Visibility reduction effects include the aesthetic degradation of the environment, an economic burden on society, and a threat to public safety.

Congress has recognized the harmful aesthetic effects of visibility reduction with the passage of the Clean Air

Act Amendments of 1977. A new section of this law, Section 116, establishes, as a national goal, the protection of visibility in federally mandated Class I areas.

In addition to aesthetic degradation of the environment, reduction in visibility creates an economic burden upon most communities and can be a threat to public safety. Among the operations which are adversely affected are those related to airports, highways, and homes.

1. Effects on Airports

Airport operations may be affected by reduced atmospheric visibility. When the air traffic pattern is slowed due to delays in take-offs and landings, operational costs are increased. Additional hazards to safety are imposed which may result in deaths, personal injury, or property damage. The passengers may be inconvenienced, especially if operations are closed. Business is indirectly affected when the businessman fails to meet his appointments in some distant city. If reduced visibility becomes frequent, enlarged or additional facilities may have to be built to compensate for the reduced speed with which air traffic can be handled. Perhaps the airport will need to be relocated to an entirely different community if reduction in visibility becomes exceedingly severe. Such would be a great economic loss to the community near which the airport is presently located.

2. Effect on Highways

Impairment of atmospheric visibility affects traffic on highways and city streets. Automobile traffic may be slowed; traffic arteries leading to and from great

metropolitan areas may become clogged to the point of stand-still. When the motorist's vision is limited, accidents, bodily injury, deaths, and property damage increase. These lead to increased insurance rates. Additional highways may be needed to compensate for the reduced flow of traffic; this means more money, and the money will come from the public, probably through increased taxes.

3. Effect on Electricity Demand

Another economic burden is the increased cost of electricity due to additional usage of lighting on streets and in the home when the pall of the community becomes dense so that adequate sunlight is unable to penetrate.

Visibility reduction is caused by the scattering and absorption of light by particles or gases in the atmosphere, and depends in a complicated way on the concentration and properties of the gases and particles present. The individual and synergistic effects of particulates, sulfur oxides, and nitrogen oxides result in the major effects on visibility by air pollutants.

Particles suspended in the air reduce visibility, or visual range, by scattering and absorbing light coming from both an object and its background, thereby reducing the contrast between them. Moreover, suspended particles scatter light into the line of sight, illuminating the air between, to further degrade the contrast between an object and its background.

The scattering of light into and out of the line of viewing by particles in the narrow range of 0.1 to 1 micron

in radius has the greatest effect on visibility. Certain characteristics of behavior of these particles make it impossible to formulate a useful approximate relationship between visual range and concentrations of particulate matter:

$$L_v \simeq \frac{A \times 10^3}{G'}$$

Where G' = particulate concentration (micrograms per cubic meter)

L_v = equivalent visual range, and

A = 0.75 for L_v expressed in miles.

The value of 0.75 for A is the mid-range value empirically obtained from observations in a variety of air pollution situations. The data indicate that the range 0.38 to 1.5 covers virtually all cases studied. The relationship does not hold at relative humidities above 70%, nor does it apply to fresh plumes from stacks, and it may not hold for the products of photochemical reactions.

Within the limitations prescribed, the relationship provides a useful means of estimating approximate visual range from particulate concentrations. In addition to aesthetic degradation of the environment, reduced visibility has serious implications for safe operation of aircraft and motor vehicles. At a visual range of less than 5 miles, operations are slowed at airports because of the need to maintain larger distances between aircraft. Federal Aviation Administration restrictions on aircraft operations become increasingly severe as the visual range decreases below 5 miles. Using the upper and lower bounds of the relationship described above, visibility could be 5 miles at a particulate loading as high as 300 micrograms per cubic

meter or as low as 75 micrograms per cubic meter. However, on the average, visibility can be expected to be reduced to approximately 5 miles at a particulate concentration of 150 micrograms per cubic meter. At a level of 100 micrograms per cubic meter, visibility is reduced to about 7 1/2 miles. This limited distance, however, may be related to particulate concentrations as low as 50 micrograms per cubic meter and as high as 200 micrograms per cubic meter.

The normal existing background levels for particulate matter in rural North Dakota are approximately 25 micrograms per cubic meter, annual geometric mean. The predicted average visibility at this level would be 30 miles. The extremes of visibility would be from 15 to 60 miles. From Table 13, the maximum change in annual particulate levels due to the Level 1 and Level 2 projects is 3 micrograms per cubic meter or an increase of rural annual geometric mean particulate concentrations from 25 micrograms per cubic meter to 28 micrograms per cubic meter. This would reduce the average visibility from 30 miles to 26.8 miles or an 11% reduction. The extremes of visibility would be reduced from 15 to 13.6 miles and from 60 to 53.6 miles.

The scattering of light is the most important effect of sulfur oxides pollution. The exact contribution that the oxides of sulfur make to the total scattering of light by various atmospheres has not been well studied. The sulfur oxides products that cause light scattering are sulfuric acid mist and other sulfate salt particulates. Because these compounds are hygroscopic and also because their rate of formation is affected by moisture in the air, their effects on visibility increase with increasing relative humidity. Visibility is reduced by sulfuric acid mist and sulfate salt particulates, and is further reduced by other particulate matter suspended in the air.

The scattering of light into and out of viewing by particles in the narrow range of 0.1 to 1 micron in radius has the greatest effect on visibility. Of the total suspended particulate matter in urban air, commonly from 5% to 20% consists of sulfuric acid and other sulfates, and of these, 80% or more by weight are smaller than 1 micron in radius. Consequently, suspended sulfates in the air can contribute significantly to reduction in visibility.

Characterstic behavior of suspended particles in the size range mentioned makes it possible to relate visual range to concentrations of overall particulate matter. Since sulfur dioxide levels, in general, correlate with levels of overall suspended particulate matter, and since the ratio of sulfur dioxide to suspended sulfate can be estimated, given the relative humidity, it is possible to estimate visibility for various relative humidities from sulfur dioxide concentration.

Although direct measurements are not available, the likely effect of sulfuric acid and sulfate salts on visual range can be estimated from existing data on particle size distribution, refractive indices, and concentrations. Because of changes in particle size, at a given concentration of sulfuric acid mist or sulfate salts, visual range is affected more and more as relative humidity increases. If only sulfuric acid mist were involved, at 50% relative humidity, the estimated visual range would be about 100 miles at a concentration of 10 micrograms per cubic meter, but only about 1 mile at a concentration of 1,000 micrograms per cubic meter. At 98% relative humidity, the estimated visual ranges at the same concentrations would be, respectively, 10 and 0.10 mile. With a normally associated amount of sulfuric acid mist and other particulate matter present, the estimated visual ranges at 50% relative

humidity would be about 50 and 0.5 mile at measured sulfur dioxide concentations of 26 micrograms per cubic meter and 2,600 micrograms per cubic meter (0.01 and 1 part per million), respectively. At 98% relative humidity, the estimated visual ranges at the same concentrations would be about 15 and 0.2 miles, respectively. Visibility would be reduced to about 5 miles at a sulfur dioxide concentration of 260 micrograms per cubic meter (0.10 part per million) at 50% relative humidity and 78 micrograms per cubic meter (0.03 part per million) at 98% relative humidity.

The normal existing background level for sulfur dioxide in rural North Dakota is approximately 5 micrograms per cubic meter, annual arithmetic mean. The predicted average visibility at this level would be 280 miles and 150 miles at 50% and 98% relative humidity, respectively. From Table 13, the maximum change in the annual sulfur dioxide levels due to level 1 and Level 2 projects is 2.5 micrograms per cubic meter, or an increase of rural annual arithmetic mean sulfur dioxide concentration from 5 micrograms per cubic meter to 7.5 micrograms per cubic meter. This would reduce the average visibility from 280 to 187 miles at 50% and 150 to 100 miles at 98% relative humidity, or a 33% reduction.

These predicted visibility ranges for sulfur dioxide are much greater than those calculated for particulates; therefore, it can be expected that particulates are the governing pollutants and are the most critical.

Observed limits of visibility at given sulfur dioxide concentrations may, however, depart from the calculated values, depending on the concentration of particulate matter and the oxidizing quality of the atmosphere.

An effect of reduced light transmission is a reduction in solar energy reaching the ground, which in turn contributes to atmospheric stability and, consequently, to the further buildup of pollutants. The oxides of sulfur do not in themselves contribute significantly to the loss of solar energy reaching the ground, but other light-attentuating particulates and gases present in fogs do so. Consequently, fogs last longer, and additional sulfuric acid mist forms, and because of its hygroscopic nature, contributes to longer lasting fogs.

Nitrogen dioxide is intensely colored and absorbs light over the entire visible spectrum, but primarily in the shorter wavelengths, violet, blue, and green. In the atmosphere it reduces the brightness and contrast of distant objects, and causes the horizon sky and white objects to appear pale yellow to reddish-brown. A token amount of light is attentuated by the molecular scattering effect of nitrogen dioxide.

The additional presence of particulate matter tends to mask the coloration effect of nitrogen dioxide, but the two combined markedly reduce the visibility, contrast, and brightness of distant objects. Particulate matter and aerosols are present in the atmosphere as primary pollutants from urban sources such as industrial combustion and vehicular transportation, and from natural sources such as the sea, soil, and fog. They are also formed through photochemical reactions and are considered to be the major cause of the reduced visibility associated with photochemical smog.

The photochemical system involves nitrogn oxides and hydrocarbons in the formation of visibility-reducing aerosols. Light scattering associated with the presence of

aerosols is the primary cause of visibility reduction in photochemical smog; absorption of light by nitrogen dioxide makes a minor contribution.

In summary, it can be concluded that the projected increase in emissions from the Level 1 and Level 2 projects will cause a reduction in visibility. The emissions of particulates from the facilities appears to be more critical than sulfur oxides emissions.

The worst case visibility reduction, based on annual particulate concentrations, apears to be approximately 11% in Mercer and Oliver Counties. The average reduction throughout the seven county study area would be much less than this.

Effects on Water Quality

The effects of air pollution on the quality of surface and ground water have yet to be clearly delineated.

The ultimate fate of air pollutants, once they are emitted into the atmosphere, is the continual deposition on the earth's surface, both water and land. Some of the pollution undoubtedly moves into the upper atmosphere where it can remain for long periods of time, until it is washed out.

Pollutants can enter surface waters directly or be transferred from land deposition by rain runoff. Pollutants can enter ground water by perculation of rainfall through the soil or from surface water reservoirs.

The major effect on water quality is that of acidity. Oxides of sulfur and nitrogen are converted to acids in the atmosphere, thus increasing rainfall acidity. This acidic

rainfall can enter surface water directly or indirectly by runoff from land and may increase the acidity of the water. In addition, acidic rain water can dissolve and leach soil minerals and trace elements and transfer them to both surface and ground waters.

In addition, toxic chemicals and trace elements can enter surface water directly from pollutants in the atmosphere causing potential adverse effects on water quality.

The information necessary to quantify the effects of air pollution on the water quality in the seven county study area is not presently available. Therefore, it is not possible to conclude whether or not the problem is significant.

The State Department of Health is aware of the potential problems and will continue conducting necessary research and monitoring to protect water quality from possible adverse effects of air pollution.

Effects on Weather

Public concern about "unintended effects upon the weather" has been sparked in recent years by scientists who have become concerned about the temperature stability of the earth. Scientists have debated whether the average temperature of the earth is heating or cooling: minute changes on the order of a few degrees of temperature could have a profound impact on man and the ecosystem. Such a change in temperature is caused by a change in the global radiation balance.

Local and regional scales of unintended weather changes are occurring because of man's activities. Large

metropolitan cities such as Chicago and St. Louis clearly modify the weather by increasing the number and severity of storms. The temperature, humidity, clouds, precipitation (rain, hail, and snow), wind, visibility, and air composition are changed by large cities.

Agricultural practices over the southern Great Plains states which exploited the land likely contributed to the "dust bowl" of the dirty thirties. In contrast, studies of historical weather for the large (about 18,000 square miles) irrigated areas from Texas to Nebraska suggest summer season rainfall increases of 15 to 50%, depending on the year's weather conditions; the area affected appears to be about 100,000 square miles. Apparently, irrigation over such wide areas leads to higher specific humidity with resulting lower temperatures and lower albedo (fraction of reflected solar radiation).

Agricultural practices such as crop types and grazing may cause local weather (microclimate) changes, but these changes are likely to be minor. Surface heat differentials may result from spatial differences of crop types and in arrays of crop and bare soil.

Extensive burning of crop and weed residues in Hawaii, the Phillipine Islands, and Australia have been attributed to increses and decreases in cloudiness, rainfall, and visibility. Such burning introduces large quantities of particulates which affect solar radiation influx and also affects the growth of raindrops.

In each of the instances of unintended weather changes cited above, the physical mechanisms producing the changes are not well understood, although changes were clearly evident. Identifying the weather changes in these instances

was difficult. Proving a physical relationship between the apparent cause (the city, the burning, and the large acreage of irrigation) and the weather change has been much more difficult, and has eluded scientific research.

The construction of power plants, such as those proposed for Level 1 and Level 2 projects, has potential for causing local and regional scales of unintended changes in the weather. The effects on weather by power plants will likely not be as pronounced as other observed unintended weather changes, since the inputs of heat, water vapor, and particulates are not as large. The release of heat, water vapor, and particulates can conceivably affect the albedo, specific humidity, temperature, and cloudiness with resulting affects on precipitation and visibility.

Cloud and precipitation processes are sensitive to the number, size, and type of particulates in the air from which a cloud grows and precipitation results. In fact, the process of formation of clouds depends upon the presence of minute particles, called condensation nuclei, onto which water vapor can condense and form water droplets. In clean air, air without any solid or liquid particles, coulds would not form.

The microphysical and dynamical mechanisms leading to clouds and precipitation are extremely complex. Simply stated, an excess of very small particles may inhibit precipitation processes, additional extra large particles may enhance precipitation processes, additional ice nuclei (particles which act as centers for collecting water vapor to grow ice crystals or which, when in contact with droplets colder than freezing, cause these droplets to freeze) may enhance the precipitation process, or any combination may occur.

Natural condensation nuclei include vegetative pollens, windblown soils, sea salts, volcanic ash, and meteoritic dust. Natural ice nuclei are primarily soil particles, about 1 in 10,000 atmospheric particles is an ice nuclei. Other sources of condensation and ice nuclei are exhausts of motors, furnaces, industrial processes, and power plants. Particulate emissions and conversion of gases to particles in plumes of power plants can create active condensation and ice nuclei.

A study ("Weather Modification Potential of Coal-Fired Power Plants," Department of Atmospheric Sciences, University of Wyoming) of two power plants was conducted during 1976: the Jim Bridger plant at Rock Springs, Wyoming, and the Colstrip Unit One plant located at Colstrip, Montana. The Jim Bridger plant operates typically at 650 megawatts, but is capable of producing 1,000 megawatts. The Colstrip Unit One plant was operating at about 250 megawatts during the study, but is capable of operating at 360 megawats. Both plants had electrostatic precipitators which were operating during the collection of data for the study. An aircraft equipped with instruments for measuring particles made several data gathering flights through the plumes of the two plants.

The study emphasized an assessment of effects upon precipitation by particulates contained in plumes of the two plants. Some results of the study include:

1. A production rate of about 10^{15} per second condensation nuclei was observed for the Jim Bridger plant and 10^{14} per second for the Colstrip Unit One plant. In the worst case of a thunderstorm located downwind of the plant, moving toward the plant, and having an influx of air of 10^{9} cubic meters per second, the increase in the

condensation nuclei above existing background concentrations in the influx of air is only about 20%. This would change the mean drop size by about 3 to 7%. If the precipitation was formed in the absence of ice crystals, the effect might cause a minor change (increase or decrease) in precipitation. However, other studies have demonstrated that precipitation over the Northern Plains depends upon the presence of active ice nuclei: this process is probably less sensitive to changes in the droplet spectrum.

2. The maximum ice nucleus concentration measured in the plume was 0.3 per liter of air at -16°C; a number marginally greater than background concentrations. However, current sample collection methods do not provide the required accuracy. Further, other studies have demonstrated very little relationship between ice nucleus concentrations in clouds and observed ice cyrstal concentrations; either instruments are in error, or ice crystal multiplication occurs, or both.

   The addition of ice nuclei could increase or decrease precipitation, depending upon how many ice nuclei are already present and how many are added. Indications are that there are insufficient ice nuclei concentrations to create precipitation effectively, and that addition of ice nuclei would increase precipitation in most cases.

In summary, the study concluded that additional condensation nuclei may cause small effects (increases or decreases) in the limited region of the plume, but the effects are probably negligible compared to natural year-to-year variations. Although the ice nuclei measurements indicate the plants are not an important source of ice

nuclei, the measurements are of questionable validity. The results should not be extrapolated to larger plants or interacting plumes of two or more plants due to the non-linear nature of emission and dispersion processes as well as precipitation processes.

Although studies suggest unintended effects of power plants on weather are negligible, larger changes of 5 to 10% decreases or increases in summer precipitation can significantly affect crop and grassland yields. Similarly, increases in winter snowfall would increase the costs of wintering cattle, snow removal, and transportation. Additional research is needed: such research requires complex and sensitive technical equipment and highly trained personnel. This type of research is time-consuming and costly. The Department of Health will continue to examine new research findings and will encourage research when appropriate to do so.

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Other Changes

Map 3-2, "Projected Annual Concentrations of Sulfur Dioxide from all Existing and Proposed Sources," found on page 81 in the Draft Study, is replaced by Map 3-2/5, which follows. Map 3-5, "Projected Annual Concentrations of Sulfur Dioxide from all Existing and Proposed Sources - Level 2," found on page 86 in the Draft Study, is also replaced by Map 3-2/5. NOTE: Clean Air Act Amendments of 1977 will not allow any additional emissions from Coyote 2 (the only Level 2 facility); thus, no change in total emissions and subsequent ground level concentrations from Level 1 and Level 2 projects.

Figure 2-1, page 28, "Occurance" in title should be spelled "Occurrence."

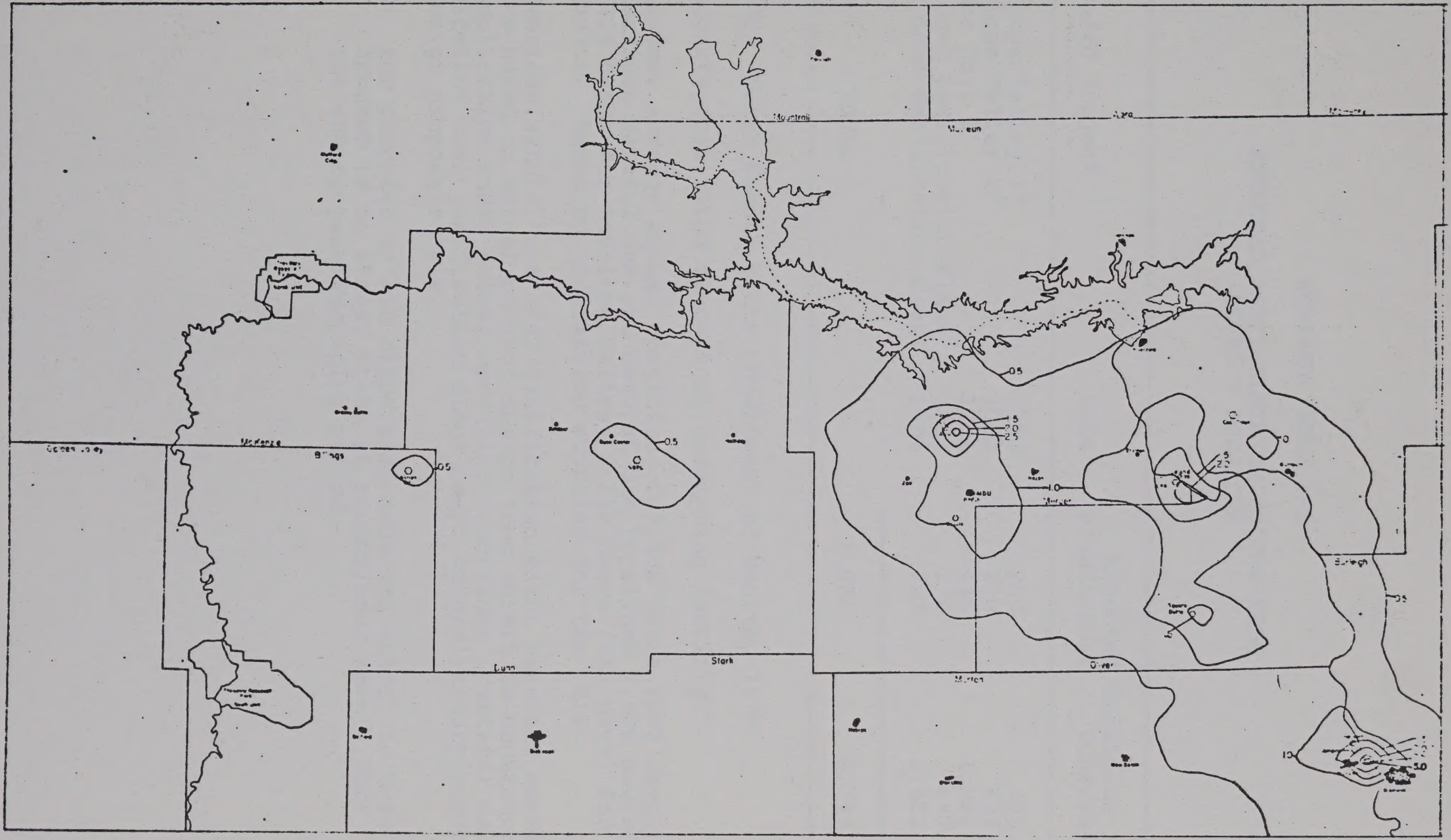
In Table 2-1, page 27, change column heading "Percent of Missing Data" to "Days of Missing Data in Percent." Also change columm heading "Climatic Elements Included (percent of total)" to "Climatic Elements Included (percent of total data obtained on days which data was collected)."

In Table 2-7, page 30, change all "26.1" with footnote "2" under comumn heading "Hourly Recorded Maximum, 1975" to "ND[2]."

In Table 2-9, page 30 change all "19" with footnote "2" under column heading "Hourly Recorded Maximum, 1975" to "ND[2]."

In Table 2-11, page 31, change SOURCE from "38 Code of Federal Regulations 25678, September 14, 1973" to "40 CFR Part 50, 1976."

REVISED MAP 3-2 AND MAP 3-5
PROJECTED ANNUAL CONCENTRATIONS OF SULFUR DIOXIDE (SO_2) FROM ALL EXISTING AND PROPOSED SOURCES


Mountrail
McLean
Ward
McKenzie
Golden Valley
Billings
Dunn
Stark
Mercer
Oliver
Morton
Burleigh
MDU
0.5
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.05
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REVISED TABLE 3-1

EXPECTED PARTICULATE EMISSIONS FROM LEVEL 1 PROJECTS

Proposed Project	Date	Expected Emissions pounds/hour	tons/year[2]
Antelope Valley 1[1]	1981	210	829
Antelope Valley 2[1]	1982	210	829
Coyote Unit 1[1]	1981	445	1,832
ANG Coal Gasification Plant[3]	1981	170	677
NGPL Coal Gasification Plant[3]	1984	397	1,582
TOTAL		1,432	5,749

SOURCE: North Dakota State Department of Health, 1978.

[1] Lignite coal-fired electrical generating facility.

[2] Assumes average annual operation of 7,968 hours (332 days) for American Natural Gas and Natural Gas Pipeline; 7,896 hours (329 days) for Antelope Valley; 8,232 hours (343 days) for Coyote. Based on information supplied for the REIS.

[3] American Natural Gas coal gasification plant expected emissions are based on actual project design from Permit to Construct application under normal operating conditions. Natural Gas Pipeline coal gasification plant based on preliminary project design proposals only.

NOTE: For purposes of air dispersion modeling emissions were assumed to be steady state at pounds/hour levels for the entire year averaging period.

REVISED TABLE 3-6

EXPECTED SULFUR DIOXIDE EMISSIONS FROM LEVEL 1 PROJECTS

Proposed Project	Date	Expected Emissions pounds/hour	tons/year[2]
Antelope Valley 1[1]	1981	1,922	7,588
Antelope Valley 2[1]	1982	1,922	7,588
Coyote Unit 1[1]	1981	5,335	21,959
ANG Coal Gasification Plant[3]	1981	3,081	12,275
NGPL Coal Gasification Plant[3]	1984	2,914	11,609
TOTAL		15,174	61,019

SOURCE: North Dakota State Department of Health, 1978.

[1] Lignite coal-fired electrical generating facility.

[2] Assumes average annual operation of 7,968 hours (332 days) for American Natural Gas and Natural Gas Pipeline; 7,896 hours (329 days) for Antelope Valley; 8,232 hours (343 days) for Coyote. Based on information supplied for the REIS.

[3] American Natural Gas coal gasification plant expected emissions are based on actual project design from Permit to Construct application under normal operating conditions. Natural Gas Pipeline coal gasification plant based on preliminary project design proposals only.

NOTE: For purposes of air dispersion modeling emissions were assumed to be steady state at pounds/hour levels for the entire year averaging period.

REVISED TABLE 3-8

PREVENTION OF SIGNIFICANT DETERIORATION OF AIR QUALITY, MAXIMUM ALLOWABLE SULFUR DIOXIDE CONCENTRATION

Pollutant Averaging Time Period	Class II[1] (μg/m^3)[3]	Class I[2] (μg/m^3)[3]
Sulfur Dioxide		
Annual arithmetic mean[4]	15	2
24-hour[4]	91	5
3-hour[4]	512	25

SOURCE: North Dakota State Department of Health Air Pollution Control Regulations, 1978.

[1] Existing sulfur dioxide classification in the seven-county study area.

[2] Mandatory classification over the Theodore Roosevelt National Park and the Lostwood National Wilderness Area.

[3] Micrograms per cubic meter of air.

[4] Annual arithmetic mean cannot be exceeded, 24-hour and 3-hour is allowed no more than one exceedance per year.

REVISED TABLES 3-10 AND 3-21

SHORT-TERM SULFUR DIOXIDE ~~(SO_2)~~ ANALYSIS
LEVEL 1 AND LEVEL 2 PROJECTS

Atmospheric Stability Class	Distance North of ANG/Antelope Valley Site Boundary Wind from South (miles)	Projected Increased Ground Level Concentrations (µg/m^3)1/			Background Concentrations (µg/m^3)			Total Projected Concentrations (µg/m^3)		
		1-hr	3-hr	24-hr	1-hr	3-hr	24-hr	1-hr	3-hr	24-hr
A	Site Boundary	126.1 (331.3)2/	78.5 (206.2)	30.8 (80.9)	105	35	25	231.1 (436.3)	113.5 (241.2)	55.8 (105.9)
B	0.8	63.8 (135.2)	39.7 (84.2)	15.6 (36.7)	105	35	25	168.8 (240.2)	74.7 (119.2)	40.6 (61.7)
C	Site Boundary	117.1 (230.9)	71.4 (140.8)	28.1 (55.4)	105	35	25	222.1 (335.9)	106.4 (175.8)	53.1 (80.4)
C	1.23/	122.6 (241.7)	74.8 (147.5)	29.5 (58.1)	105	35	25	227.6 (346.7)	109.8 (182.5)	54.5 (83.1)
D	8.1	88.9 (153.3)	55.0 (94.7)	21.9 (37.9)	105	35	25	193.9 (258.3)	90.0 (129.7)	46.9 (62.9)
E	36.0	84.2 (120.0)	51.9 (74.0)	20.7 (29.6)	105	35	25	189.2 (225.0)	86.9 (109.0)	45.7 (54.6)
F4/	---	---	---	---	---	---	---	---	---	---
State Ambient Air Quality Standards								715		260
Federal Ambient Air Quality Standards									1300	365
State Class II Prevention of Significant Deterioration Allowable Increment			512	91						

SOURCE: North Dakota State Department of Health 1978

1/ Abbreviation for micrograms per cubic meter.

2/ Numbers in parenthesis ( ) are projected ground level concentrations based upon outdated emissions of SO_2 presented in the Draft ~~REIS.~~ Study. These numbers are included for comparison purposes.

3/ These concentrations were estimated to occur with the wind from the north. Therefore, ground level concentrations south of the ANG/Antelope site boundary--thus no contribution from Coyote.

4/ The projected concentrations under F stability class were found to be lower than those concentrations under E stability class for all cases. Also the distances to the point of maximum concentrations are too great such that meteorological conditions are not likely to persist long enough for the plume(s) to travel that far. The stability class is a measure of the ability of the atmosphere to disperse emissions. Generally, Classes A, B, C, and D favor rapid dispersion where as the more stable Classes, E and F, are associated with poor dispersion.

REVISED TABLE 3-11

EXPECTED NITROGEN DIOXIDE EMISSIONS FROM LEVEL 1 PROJECTS

Proposed Project	Date	Expected Emissions pounds/hour	Expected Emissions tons/year[2]
Antelope Valley 1[1]	1981	2,465	9,732
Antelope Valley 2[1]	1982	2,465	9,732
Coyote Unit 1[1]	1981	3,190	16,094
ANG Coal Gasification Plant[3]	1981	536	2,135
NGPL Coal Gasification Plant[3]	1984	2,855	11,374
TOTAL		12,231	49,067

SOURCE: North Dakota State Department of Health, 1978.

[1] Lignite coal-fired electrical generating facility.

[2] Assumes average annual operation of 7,968 hours (332 days) for American Natural Gas and Natural Gas Pipeline; 7,896 hours (329 days) for Antelope Valley; 8,232 hours (343 days) for Coyote. Based on information supplied for the ~~REIS~~. Draft St. Dy

[3] American Natural Gas coal gasification plant expected emissions are based on actual project design from Permit to Construct application under normal operating conditions. Natural Gas Pipeline coal gasification plant based on preliminary project design proposals only.

NOTE: For purposes of air dispersion modeling emissions were assumed to be steady state at pounds/hour levels for the entire year averaging period.

REVISED TABLE 3-19 AND 3-23

PROJECTED MAXIMUM SHORT-TERM AIR CONTAMINANT IMPACTS UPON FORT BERTHOLD INDIAN RESERVATION
LEVEL 1 PROJECTS

Total Suspended Particulate (micrograms per cubic meter of air)			Sulfur Dioxide (micrograms per cubic meter of air)					
Projected Concentration	Background Concentration 24-Hr	Total Concentration 24-Hr	Projected Concentration 3-Hr	Projected Concentration 24-Hr	Background Concentration 3-Hr	Background Concentration 24-Hr	Total Concentration 3-Hr	Total Concentration 24-Hr
2	80	2 (82)[1]	60.9	24.4	35	35	60.9 (95.9)	24.4 (49.4)
STANDARDS		30[2] 150[3]					512[2] 1,300[3]	91[2] 365[4]

SOURCE: North Dakota State Department of Health, 1978.

NOTE: The maximum ground level concentration was projected to occur at the southern boundary of the Fort Berthold Indian Reservation. The distance from this boundary to the north boundary of the Antelope Valley Complex is eight miles.

¶ Addition of Coyote 2 to the particulate ground level concentration over Fort Berthold Reservation is negligible. Sulfur dioxide GLC would be the same as Level 1 concentration

[1] Numbers in parenthesis have background added in and are to be compared to Ambient Air Quality Standards. Numbers without parenthesis are counted against Prevention of Significant Deterioration of Air Quality increments.

[2] Prevention of Significant Deterioration of Air Quality increments (Class II).

[3] Maximum allowable concentrations for Federal Secondary (most stringent) Ambient Air Quality Standard.

[4] Maximum allowable concentration for Primary Ambient Air Quality Standard.

In Table 3-4, page 29, the reference for Oxides of Nitrogen Emissions in footnote 4 should be changed to Federal New Source Performance Standard for lignite as stated in Federal Register Vol. 43, No. 45, Tuesday, March 7, 1978, pp. 9276-9278. (NOTE: 0.6 lb/10^6 Btu input for all types of lignite-fired boilers except cycline-fired boilers where the emission regulation is 0.8 lb/10^6 Btu input for lignite coal found in North Dakota, South Dakota, and Montana.) Also, 0.6 lb/10^6 Btu input should be added under the North Dakota Standard column where deleted.

In Table 3-20, page 86, a footnote "3" should be added above Coyote 2 Power Plant. Footnote 3 should be changed as follows: Assumes average annual operations of 8,232 hours (343 days) as expressed in Permit to Construct application.

In Table 4-1, page 149, the source should be changed to: 40 CFR Part 50, 1976.

In Table 4-3, page 150, the reference for Oxides of Nitrogen Emissions in footnote 4 should be changed to: Federal New Source Performance Standard for lignite as stated in Federal Register Vol. 43, No. 45, Tuesday, March 7, 1978, pp. 9276-9278. (NOTE: 0.6 lb/10^6 Btu input for all types of lignite-fired boilers except cyclone-fired boilers where the emission regulation is 0.8 lb/10^6 Btu input for lignite coal found in North Dakota, South Dakota, and Montana.) Also, 0.6 lb/10^6 Btu input should be added under the North Dakota Standard column where deleted.

In Table 45, page 150, a footnote "3" should be added above Coyote 2 Power Plant. Footnote 3 should be changed as follows: Assumes average annual operation of 8,232 hours (343 days) as expressed in Permit to Construct application.

PROPOSED ACTION

INTRODUCTION

Comments were received from several individuals, industries, and government agencies indicating corrections to project related data. Some comments also requested clarification related to transmission line mileage and acreage figures.

Corrections and errors in the text and tables were noted, and where significant numerical differences were found, they were passed on to resource specialists for use in their updates. A review was made of the acreage figures and an explanation provided to clarify the numbers and their relationship. The transmission line mileage was rechecked with each company, and the latest figures were shown.

Some individuals, one industry, and one environmental group questioned why the NGPL project was analyzed in Level 1 development. The basis for the projects selected for Level 1 development came from criteria established for each level of development prior to the study, and the fact that NGPL meets all of this criteria for Level 1 development is repeated.

One state legislator and several other individuals commented on the need for clarity of the surface owner protection provisions of the state and federal acts. Also, some legal questions were raised on liability. A review was made of the state Surface Owner Protection Act and the surface owner consent provision of the Surface Mining Control and Reclamation Act. A summary now clarifies the concerns raised in the comments. The legal questions were reviewed by the Attorney General's office, but ~~it was determined that~~ the information was insufficient for an appropriate ~~general~~ response. Most of these legal person~~nel~~al questions should be referred to one's own attorney.

A comment was received by an individual on the oil and gas development in Dunn and Stark Counties. Additional research was conducted on the extent of this development and an update of the oil and gas development is included.

The "alternatives" chapter was commented on by one environmental group. A review of the alternatives was made based on each comment. Many of the comments appeared to be directed at the national issues and not at regional alternatives. These comments could not be addressed until some of the national programs and policies have been established. It should also be pointed out that the Draft Study did not repeat national alternatives analyzed elsewhere, but instead references them. Other comments appeard to be made after reading only the Summary. References were made to the text of the entire Draft Study.

MODIFICATIONS AND CORRECTIONS

Synthetic Natural Gas Production

The ANG Coal Gasification Company still plans to construct the project. However, because of the cost of gasification plants and the current financial situation, a consortium has been formed to construct the Great Plains Gasification Project. The group is currently made up of subsidiaries of American Natural Resources Company, Peoples Gas Company, Columbus Gas System, Inc., Tenneco, Inc., and Transco Companies, Inc.

The permits or approvals that were necessary for construction of the gasification projects which have been received (page 8 of the Draft Study) are modified to include:

ANG Coal Gasification Company

a. Mercer County Board of Commissioners - Conditional Use Permit, April 1977.

b. Public Service Commission - Site Compatibility Permit, November 1977.

c. North Dakota State Health Department - Permit to Construct, November 1977.

The ANG Coal Gasification Company project was originally scheduled to begin construction in 1978. This schedule has been delayed, and construction is scheduled for spring 1979.

Electric Power Generation

The two electric power generation plants, Coyote 1 and Antelope Valley, have received all of the permits necessary for construction of the plants. The Coyote 1 station started construction in October 1977 and the Antelope Valley Station began in July 1978.

Oil Production: Dunn and Stark Counties

The discovery of oil in Dunn County in 1976 indicated a potential for increased oil production in the area. The field which has shown great promise is the Little Knife field in Dunn, Billings, and McKenzie Counties. During 1977, this field produced 1,104,068 barrels of oil. At the present time, the field has 54 wells, 22 of which are producing both oil and gas. Prior to the summer of 1978, the wells were restricted to 100 barrels per day. In the summer of 1978, a gas plant was put in operation and the field should be producing about 9 million cubic feet of natural gas per day and between 8,000 and 20,000 barrels of oil per day. It is expected that by the end of 1978, there will be 90 wells drilled in the field and another 60 wells are expected to be drilled in 1979.

Table 1-28 on page 23 of the Draft Study which presents oil production figures for Dunn and Stark Counties should be updated as follows:

County	Field	Production (barrels) 1977 (Annual)	Production (barrels) 1978 (Through May)	
Dunn	Haliday	12,228	5,557	(shut-in first 3 months)
	Haystack Butte	0	6,085	
	Killdeer	113,204	37,707	
	Little Knife[1,2]	1,104,068	812,489	
	Oakdale	31,344	13,440	
	Rattlesnake Point	33,117	34,407	
	Russian Creek[3]	0	16,340	
Stark	Buffalo Creek	18,964	7,899	
	Dickinson	1,684,883	645,582	
	Green River	117,614	33,614	
	Rocky Ridge[4]	135,746	50,396	
	South Heart	105,117	24,929	
	Zenith	122,587	40,696	
TOTAL		3,478,872	1,729,141	

SOURCE: North Dakota Geological Survey, May 1978

1/ Field covers portions of Dunn, Billings, and McKenzie Counties.

2/ Production was restricted to 100 barrels per day until summer~~y~~ 1978 when gas plant became operational.

3/ This field started production in January 1978.

4/ Field covers portions of Stark, Slope, and Billings Counties.

Other Changes

Draft Study

Map 1-1 preceding page 1 should be modified as follows:

1. Symbol number 4 in red representing the Coyote Station of Level 1 development should be an Electric Power Plan~~g~~t symbol.
2. The pipeline in McLean county for Level 1 development should be labeled 20" Synthetic Natural Gas.

3. Item 3 of the black legend should read Basin Electric Power Cooperative-Leland Olds Station
4. The definition of Level 1 Proposals in the red legend should read, "Projects proposed by industry, which would be expected to initiate construction within about 5 years, if approved."
5. The railroad symbol in the red legend should have cross ties.
6. The definition of Level 2 Proposals in the blue legend should read, "Projects proposed by industry, which would be expected to initiate construction by 1980, if approved."

On page 1, column three, the last sentence ~~,~~ should read (The Bureau of Reclamation's ANG Final Environmental Impact Statement (1978) has complete site specific details.)

On page 1, column four, the last sentence should read (Rural Electrification Administration's D~~d~~raft Environmental Impact Statement (1978) has complete site specific details).

On page 2, column one, first paragraph, last sentence, "Statement" should be changed to "Study,."

The figure on the page between pages 2 and 3 should be labeled "Figure 1-2" and show the following as the source: AMAX Coal Company, 1976.

On page 4, figure 1-6 should show the following source: Western Gasification Company 1978.

On page 6, figure 1-11 should show the following source: Modified from Ottertail Power Company 1977.

On page 7, column one, paragraph six, line eight, "March 1977" should be "January 1978."

On page 9, column, 2, paragraph 2, add: Of the 350 MW of power scheduled to be used within North Dakota, 160 MW will be used by ANG to produce SNG for export.

On page 9, figure 1-19 should show the following source: Ottertail Power Company 1977.

On page 9, the emission data in Table 1-5 for Basin Electric Power Plant was taken from data supplied by Basin Electric Power Cooperative in their application for Permit to Construct. Since the publication of the Draft Study, revisions were made to take into account the Clean Air Act Amendments of 1977. The following is a tabulation of the emissions currently being used to reflect the 1977 amendments:

Antelope Valley Emissions (lbs.hr.)[1,2]

TSP	420
SO_2	3845
NO_x	4930

1/ Two 440 MW units.

2/ TSP and NO_x are maximum allowable as per New Source Performance Standards.

On page 12, column one, paragraph four, line two, the word "or" should be "on."

On page 22, figure 1-26 should show the following source: Regional EIS 1977.

On page 10, Table 1-8, the mileage for the Basin Electric 500 kilovolt line should be "286" instead of "275." The 345 kilovolt line should read "52" instead of "50."

Summary

On page 5, under NGPL Coal Gasification Plant and AMAX Mine, the "southwest" on line 4 should be changed to "southeast."

On page 5, column 2, "per pound of coal" should be added after the 6,660 Btu's describing the heating value of lignite.

GEOLOGY

INTRODUCTION

The North Dakota Regional Environmental Assessment Program (REAP) referenced an unpublished report dealing with inverted overburden. A copy of the report was obtained and revisions in the text were made to indicate that surface mining operations do not generally invert the overburden, but ~~rather~~ instead bring deeper overburden near the surface at many places. REAP also referenced one of their reports on paleontologic data, but after a failure in obtaining the additional information, additional analysis was not completed.

The state Geological Survey pointed out that a search for uranium is being carried out on a statewide scale. The text of the Draft Study was revised accordingly. The state Geological Survey also felt that enough attention had not been given to the interrelationships of potential occurrence of coal and oil and gas on the same land. Chapter 38-15 of the North Dakota Century Code provides for resolution of conflicts and subsruface mining production, and includes oil and gas subsurface minerals and coal. Revisions as appropriate were made in the text and a copy of Chapter 38-14 of the NDCC is included with their letter in Part 2.

A review of the most current oil and gas activities was made as a result of a comment from the North Dakota State Water Commission. The review revealed that 40 to 50 producing wells have been drilled, with the expectation of doubling the number of producing wells during the next year.

MODIFICATIONS AND CORRECTIONS

Oil and Gas

The last paragraph of the Geology section in Chapter 2, page 35, should be revised as follows: "However, the rate of increase in production of oil and natural gas should

have little effect, except locally, on surface disturbance and population increases within the seven county study area. For example, development is occurring in the Little Knife River Field and Dunn and McKenzie Counties, and between 40 and 50 producing wells have been drilled with the expectation of doubling the number of producing wells in the next year. The field currently covers an area of about 12 square miles."

Other Minerals (Resolution of Conflicts)

Chapter 38-15 of the North Dakota Century Code provides for the resolution of conflicts on subsurface mineral protection and specifically includes oil, gas, surface minerals, and coal, including lignite. The North Dakota Industrial Commission has jurisdiction and authority to enforce provisions of the chapter, and the State Geologist is charged with the responsibility and authority to enforce the rules and regulations of the Industrial Commission applicable to the provisions of the chapter.

(Note: A copy of Chapter 38-15 of the North Dakota Century Code is included in comment #158 received from the State Intergovernmental Clearinghouse State Planning Division, North Dakota Geological Survey.)

Other Changes

Draft Study

On page 32, Topography subheading, first column, first sentence, "northeast" should be changed to "northwest." In the second paragraph, last sentence, "Cheyenne" should be "Sheyenne."

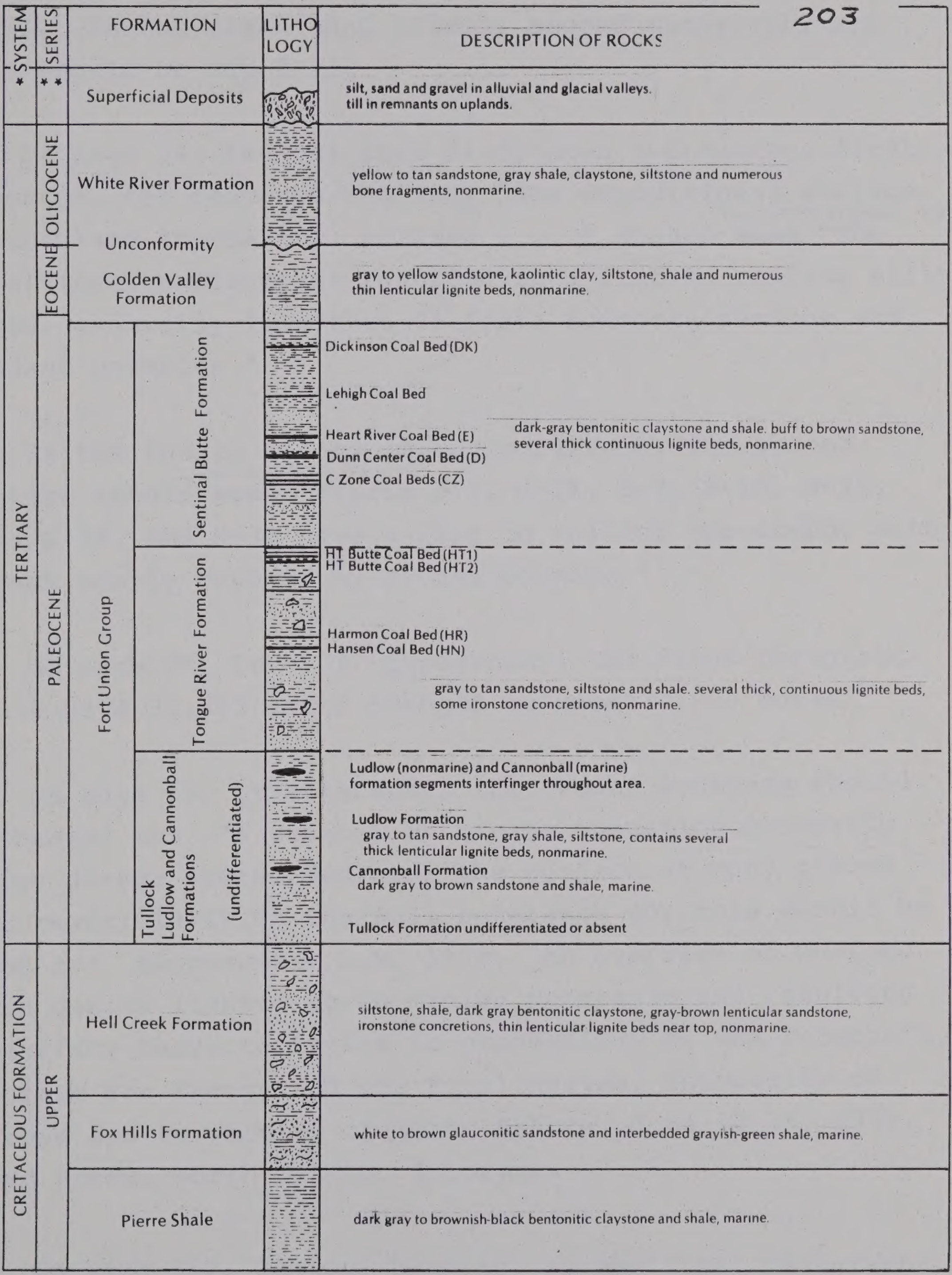
In the legend of Map 2-10, "Akaree" should be spelled "Arikaree," and "Sentinal" should be spelled "Sentinel."

¶ Figure 2-5 has been revised ~~and is shown below:~~ as follows:

~~figure 2 - 5~~

COLUMNAR SECTION OF SEDIMENTARY FORMATIONS
DUNN CENTER AREA

203



SYSTEM	SERIES	FORMATION		LITHOLOGY	DESCRIPTION OF ROCKS
*	* *	Superficial Deposits			silt, sand and gravel in alluvial and glacial valleys. till in remnants on uplands.
TERTIARY	OLIGOCENE	White River Formation			yellow to tan sandstone, gray shale, claystone, siltstone and numerous bone fragments, nonmarine.
		Unconformity			
	EOCENE	Golden Valley Formation			gray to yellow sandstone, kaolintic clay, siltstone, shale and numerous thin lenticular lignite beds, nonmarine.
	PALEOCENE	Fort Union Group	Sentinal Butte Formation		Dickinson Coal Bed (DK) Lehigh Coal Bed Heart River Coal Bed (E) Dunn Center Coal Bed (D) C Zone Coal Beds (CZ) dark-gray bentonitic claystone and shale. buff to brown sandstone, several thick continuous lignite beds, nonmarine.
			Tongue River Formation		HT Butte Coal Bed (HT1) HT Butte Coal Bed (HT2) Harmon Coal Bed (HR) Hansen Coal Bed (HN) gray to tan sandstone, siltstone and shale. several thick, continuous lignite beds, some ironstone concretions, nonmarine.
			Tullock Ludlow and Cannonball Formations (undifferentiated)		Ludlow (nonmarine) and Cannonball (marine) formation segments interfinger throughout area. Ludlow Formation gray to tan sandstone, gray shale, siltstone, contains several thick lenticular lignite beds, nonmarine. Cannonball Formation dark gray to brown sandstone and shale, marine. Tullock Formation undifferentiated or absent
CRETACEOUS FORMATION	UPPER	Hell Creek Formation			siltstone, shale, dark gray bentonitic claystone, gray-brown lenticular sandstone, ironstone concretions, thin lenticular lignite beds near top, nonmarine.
		Fox Hills Formation			white to brown glauconitic sandstone and interbedded grayish-green shale, marine.
		Pierre Shale			dark gray to brownish-black bentonitic claystone and shale, marine.

* QUATERNARY
* * PLEISTOCENE, HOLOCENE
SOURCE: Modified after Menge, 1977

[redacted]

On page 33, left column, last paragraph, the reference to Map 2-11 should be deleted. In Table 2-13 in the column under "Drill Hole 121," the bottom number should be changed to .2L. In the right hand column, second paragraph, Map 2-11A should be Map 2-11.

On page 34, Federal Coal Study Area subheading, first paragraph, the sentence reading "The depositional surface has resulted in rolling, hilling . . ." should ~~read~~ be changed to "The depositional surface has resulted in a flat to rolling hilly relief, generally less than 25 feet; hummocky surface and abundant potholes."

In the fourth column, first paragraph, the second sentence should ~~read~~ be changed to "Tracts S-1, S-2A, S-3, N-1B, N-2A, N-2B, N-3A, and N-3B have a flat to rolling ropography with bedrock mostly covered by ground moraine."

On page 89, Level 1, topography, the first paragraph should have 32,800 acres changed to ~~read~~ 34,000 acres.

On page 89, stratigraphy, the second sentence should be changed to: "A subsurface mining operation generally brings deeper overburden near the surface at many places (Winczewski 1978)." The full reference for this should be added as: Winczewski, L.M. 1978. An overview of western North Dakota lignite strip mining processes and resulting subsurface characteristics in proceedings of the International Congress for Energy and the Equal System, University of Arizona and University of North Dakota, June 12-16, 1978, Grand Forks, North Dakota, in press.

On page 169, Geology heading, ~~in the~~ first paragraph 80% should be changed to 75%. In the third column, first paragraph, 32,250 should be changed to 34,000; and 94,500 should be changed to 76,000.

On page 170, Coal subheading, first paragraph, 56.8 should be changed to 68.

On page 181, Geology heading, first paragraph, 1,035 should be changed to 1,371.

On Map 2-9, the glacial line showing the limit of ground moraine and abundant erratics should be extended in an arc towards Hebron, then followi~~ng~~ the southern boundary of the modern flood plain to the bottom of the map.

Summary

On page 13, under the Residual Impacts heading, "possibly altering the chemical properties of soil" should be deleted.

SOILS

INTRODUCTION

Public concerns regarding soils were expressed by several individual citizens and especially by representatives of the Dakota Resource Council. The primary concerns included: detail of mapping and suitability criteria, identification and analysis regarding prime farmland, separate removal and segregation of suitable plant growth material, sodium-related hazards, erosion hazards between mining and reclamation, reclamation costs, and soil productivity effects of acid rainfall.

The emphasis of soils resource analysis can be clarified by the following statement recently made by Bruce Seelig of the North Dakota Public Service Commission: "From the soils point of view, this document can be very useful if it is used as a general planning document. The information can be used for overview studies of the area and to provide information on a regional basis. When specific management decisions will be made, this document can be used to provide preliminary information to be followed by more detailed studies." On a more site specific basis, mining proposals submitted to the PSC must include a detailed soil survey which, along with test hole overburden information, would reveal the amount of suitable plant growth material available for reclamation.

The issue of prime farmland acreages also will be clarified with completion of detailed soil surveys being conducted by the Soil Conservation Service as part of the National Cooperative Soil Survey. The extent and distribution of both prime farmlands and farmlands of statewide importance is being identified. When mining prime farmland areas, the A horizon with high organic matter and the B to C horizon soil and subsoil must each be segregated and separately

stockpiled. These two materials then are to be replaced in their original order, with compaction and uniform depth, over the regraded spoil. Prime farmland considerations in facility siting is discussed in the land use section.

The concerns expressed over sodium affected materials reflect a continuing interest in this aspect of surface mining reclamation. Considering both state and federal regulations, sodium affected material and other toxic-forming materials would be buried to a minimum depth of four feet, provided four feet of nontoxic material is available. Upward migration of sodium in the soil appears to be limited to the top four inches of soil material. Continued research, however, is being conducted.

Updated federal and state regulations address the concerns over delays between mining and revegetation. Revegetation would be conducted during the first normal period for favorable planting after final grading. Otherwise, stockpiled topsoil and disturbed areas would be seeded or planted with an effective cover of non-noxious quick-growing annual and/or perennial plants or protected by other approved measures, such as mulching.

Reclamation costs are of universal concern. These costs in west central North Dakota averaged $2,500, and ranged from $2,200 to $3,000 in 1976. Reclamation cost estimates are currently being further updated by the North Dakota Public Service Commission.

The issue of acid rainfall from power plant emissions, surfaced by one concerned citizen, is not as critical to soils in North Dakota as is the case in the eastern portion of the United States. Soils in the study area tend to be

alkaline with soil reaction ranging from 7.5 to 9 The Presence of high amounts of calcium carbonate tend to buffer soil reaction near 8 (ten times more alkaline than the neutral point). Acid rainfall in the amounts projected within the study area would have a minimal effect on soils. The slight adjustment in soil reaction toward neutrality would have a negligible but slightly positive effect on plant growth by increasing availability of soil elements essential to plant growth.

MODIFICATIONS AND CORRECTIONS

Draft Study

On page 35, column 1, Soils, paragraph 2, the following two paragraphs should replace ~~be added~~: paragraph 2:

> "From the soils point of view, this document can be very useful if it is used as a general planning document. The information can be used for overview studies of the area and to provide information on a regional basis. When specific management decisions will be made, this document can be used to provide preliminary information to be followed by more detailed studies.
>
> The information provided in this ~~REIS~~ ~~Draft Study~~ OK will be useful to people making decisions on a regional or statewide basis. It will also point out areas where more information is needed. However, it will not replace the need for more detailed technical information which is needed to make management decisions on a site-specific basis." (Bruce Seelig, Environmental Scientist, North Dakota Public Service Commission)

On page 35, column 2, Soil Texture, paragraph 2, lines 3 and 4 should read: ". . . clay (less than .002 millimeter)."

On page 35, column 4, National Prime Farmland and Statewide Important Farmland, the following paragraph should be added:

"As part of the National Cooperative Soil Survey, the U.S. Soil Conservation Service in North Dakota presently is identifying prime farmland and additional farmlands of statewide importance (AFSI). Updated acreage figures are based on the published soil surveys for Burleigh, Morton, Oliver, and Stark Counties; and the completed but not published soil surveys of McLean and Mercer Counties. The soil surveys, available at the office of the State Soil Conservationist in Bismarck, are detailed and published at a scale of 1:20,000, except Morton which is 1:62,500. The survey is not completed for Dunn County."

On page 42, Table 2-27, the percentage under cropland for Burleigh County should be changed from 32,02 to 52.02

On page 91, column 2, Soils: Level 1, paragraph 3, the second sentence should be replaced with: "By following required procedures in PSC Rule 69-05-07, the high organic matter (1.5% or higher) topsoil materials would not be mixed and diluted with subsurface unweathered material."

On page 91, column 2, Soils: Level 1, paragraph 3, sentence 3 should be omitted.

On page 153, column 1, Applicants' Commitments, paragraph 3, line 11, "texture by feel" should be replaced with "texture by hydrometer or pipette method."

On page 153, column 3, Applicants' Commitments, paragraph 3, the second sentence should be changed to: "PL 95-87, Section 515(b)(3), and North Dakota PSC Rule 69-05-97-01, call for elimination of highwalls, spoil piles, and depressions."

On page 153, column 3, Applicants' Commitments, paragraph 7, the first sentence should be changed to: "A double trenching method in laying of pipelines is an unwritten policy requirement of the North Dakota Public Service Commission."

On page 153, column 4, Applicants' Commitments, continuing paragraph from column 3, the following should be added: "18 CFR 2.69 applies only to natural gas pipelines. Comparable federal regulations applicable to other pipeline excavation and reclamation are: 30 CFR 211 43 CFR 2800; U.S. Geological Survey Notice to Lessees #6; and Secretary of the Interior Order 2948."

On page 153, column 4, Applicants' Commitments, paragraph 1, the second sentence should be changed to: "Separate removal, stockpiling, and replacement of topsoil following excavation in establishment of transmission or energy conversion facilities is an unwritten North Dakota Public Service Commission policy."

On Map 2-12, the following note should be added: "For a discussion of land capability classes, see ~~text~~ page 35, column 1, Land Capability."

Patterson Lake should also be added.

On Map 2-13, the legend should be rearranged as follows:

Very High Erodibility
High Erodibility
Medium Erodibility
Low Erodibility
Mined Land (Erodibility too variable to evaluate)
Marshes and Water Surface

Patterson Lake should also be added.

On Map 2-14, the legend should be rearranged and altered to read:

Severe Hazard Areas
Low to Moderate Hazard Areas
Water

Patterson Lake should also be added.

On Map 2-15, Patterson Lake should be added.

On Map 3-7, the following note should be added: "For discussion of land suitability classes, refer to ~~text~~ page 92, column 1, paragraphs 3, 4, and 5."

WATER

INTRODUCTION

Public comments on water resources were rather evenly divided between federal agencies, state and local agencies, and Indian Reservation spokespersons. Most comments related to water use, including secondary uses associated with increased population in Dickinson and water and sewage requirements for new housing on the Fort Berthold Indian Reservation.

Many of the responses to the comments were handled simply by referring to sections of the Draft Study or the appendix where the subjects had already been covered, but apparently missed. Several responses included further clarifications or elaborations. Corrections were made to the Corps of Engineers responsibilities under Section 404 of the Federal Water Pollution Control Act, as amended in 1972. A series of comments by the City Engineer at Dickinson questioned whether industrial water supply systems for the proposed mines and gasification plans could be modified to include municipal water supplies, especially regarding Dickinson's need for an expanded water supply. There is nothing in the proposed actions to justify such a hope. Several comments from Indian spokespersons based on assumptions that water impacts would occur were answered by reiterating that such impacts would not occur.

The response to questions about the long-term effect of air emissions and of mining on water quality indicate the need for additional research and monitoring. Monitoring of hydrologic features, b~~y~~oth quantity and quality, is required under the Surface Mining and Reclamation Act of 1977. In addition, a program to monitor ground water levels and quality is already underway at several mines in the study area.

MODIFICATIONS AND CORRECTIONS

Draft Study

On page 21, column 2, at the end of the sixth paragraph, the following paragraph should be added:

> For site specific proposals that would require Corps of Engineers section 404 permits, impact statements must contain data complying with that section. However, any fills involving streams having an average annual flow of less than 5 cubic feet per second would be permitted under the "Nationwide Permit."

On page 97, column 2, paragraph 1, the second sentence should be changed to: "The Antelope Valley Power Plant would use water from the lake for generation of electric power."

On page 154, column 4, last paragraph, line 2, "Beulah" should be changed to "Dunn Center."

On Map 2-26, a scale and the names of major rivers should be added. ?

On Map 2-17, the drainage basins should have been in color and named. ?

Fort Berthold Technical Supplement

On page 54, paragraph 3 should be changed to show that the "normal maximum" capacity of Lake Sakakawea is 22,640,000 acre-feet.

On page 55, the following should be added at the end of the first sentence: "allocations from Lake Sakakawea, evapor~~t~~ation from the lake surface, and downstream water commitments."

On page 60, the first paragraph under "Residual Adverse Impacts" should be deleted.

On page 60, last paragraph, the second sentence should be changed to: "Long term effects ~~of~~ on Ft. Berthold water resources might include dewatering of aquifers within one mile of mined areas and chemical degradation of ground water if water from mine spoils moved into reservation aquifers. These effects could only occur if lignite is mined in close proximity to reservation boundaries."

On page 61, the second paragraph should be deleted.

VEGETATION

Most comments on vegetation included concerns regarding reclamation and the effects of air quality upon vegetation.

Major reclamation concerns were (1) the three to five year reclamation cycle used in the study, and (2) the reclaimability of mined lands to pre-mined productivity. These concerns were expressed by the North Dakota Resource Council, North Dakota Game and Fish Department, North Dakota State Water Commission, the North Dakota Chapter of The Wildlife Society, and several individuals. These concerns were answered with clarification and by additional research. This research included conclusions from a meeting of reclamation experts from the Northern Great Plains Experiment Station, Mandan; Agricultural Research Service; Public Service Commission; North Dakota State Planning Commission; and the Bureau of Land Management. A summary of findings were that: (1) from a technological viewpoint, the three to five year reclamation cycle is an adequate timeframe for reclamation, assuming that no special adverse problems such as excessive subsidence, extremely dry climatic cycles, excessive upward sodium migration, etc., occur; and (2) with present day reclamation technology, 100% of the pre-mined productivity can be attained for most croplands and grasslands; however, only time will provide absolute proof. Other vegetative types such as shrublands, woodlands, and wetlands require longer than three to five years to attain 100% of this pre-mined productivity. There are also still some concerns as to whether this productivity can be maintained over periods of 20 or more years.

Major concerns regarding air quality oriented toward the effects of trace elements and acid rains were expressed by the North Dakota Resource Council, North Dakota State

Water Commission, the North Dakota Chapter of The Wildlife Society, League of Women Voters of North Dakota, and several individuals. These concerns were addressed by additional research, explanations, and clarification. Information regarding the effects of trace elements and acid rain are found in Part 1, Climate and Air Quality.

~~Errata~~ only errata is that the

The word "unlikely" in line 15, ~~of the~~ fourth paragraph, ~~of the~~ fourth column, ~~of~~ page 155, of the Draft Study, should be changed to "likely."

ANIMALS

INTRODUCTION

The majority of comments on domestic animals and wildlife were concerns about possible air quality impacts. Comments on this subject were received from the North Dakota Chapter of the Wildlife Society, the Dakota Resource Council, the North Dakota State Water Commission, the League of Women Voters of North Dakota, and various individuals. These comments generally expressed the feeling that the analysis of air quality impacts avoided ~~white-washed~~ the problem by asserting that all applicable state and federal air quality standards would be met and that, therefore, there was no basis for predicting any adverse impacts. It was mentioned in several locations in the Draft Study that adverse impacts are indeed possible even though standards are met, that the studies upon which the existing standards are based do not adequately address long term synergistic effects, nor do they address many important air pollution components such as trace elements. However, Part 1 now includes an analysis by the North Dakota Department of Health that analyzes what is known about animal responses to various concentrations of pollutants.

The Bureau of Reclamation pointed out that greater attention should have been given to the fact that post-mining land uses generally would be different from pre-mining land uses and that in most cases these changes would be harmful to wildlife. Although this impact was mentioned in several places in the Draft Study, several additional paragraphs of discussion on this subject included herein again conclude that locally and cumulatively such land use changes could have a significant impact on game and non-game wildlife.

The Bureau of Reclamation pointed out that high voltage transmission lines do not present an electrocution hazard to raptors because the distance between conductors on these lines is greater than the wing span of even the largest eagles. This fact was verified and our analysis was changed to conclude that except for smaller distribution lines, most of which would be outside the seven county study area, no bird losses from electrocution would be anticipated.

The North Dakota Regional Environmental Assessment Program pointed out that a very recent publication by Robert Seebloom concludes that the acreage of prairie dog towns in North Dakota has been increasing in recent years, apparently as a result of the cecession of poisoning programs in North Dakota. The studies used in our analysis concluded that prairie dogs were decreasing. The issue is important because prairie dog towns can be important habitat for the endangered black-footed ferret. Several paragraphs were revised to show that the increase in prairie dog towns pointed out by Seebloom's study indicates a growing opportunity for the return and increase of the ferret. This change does not, however, affect the original conclusion that ferret impacts because of either Level 1 or Level 2 development are still considered to be remote.

The North Dakota Game and Fish Department questioned the meaning of several passages and pointed out several technical errors involving the current status of the bald eagle and the citation of references. Some of these concerns had already been identified through a rather intensive review of the draft conducted by the Animals Work Group, and are clarified or amended under the headings ~~below.~~ that follow.

The review by the Animals Work Group discovered the failure to include the location of black-footed ferret sitings on the endangered species map and the incorrect listing of the Northern Kit (or Swift) Fox as an officially listed federal endangered species. The update below includes the location of the ferret sitings. There is also an explanation that although *Vulpes velox hebes* (Northern Kit or Swift Fox) is officially endangered in Canada and is observed occasionally in several northern states, including North Dakota, it is not officially an endangered species in the United States, but is, however, recognized as being "rare and endangered" by the state of North Dakota.

An update explains that proposed designations of critical habitat for the endangered whooping crane within the seven county study area must be re-proposed in the Federal Register under new criteria established in recent amendments to the Endangered Species Act.

MODICATIONS AND CORRECTIONS

Post-Mining Land Use Decisions on Wildlife

Data on post-mining land uses for previously strip mined areas is available, but has not been compiled (Klein 1978, personal communication). Such compilation might lead to better understanding of this impact.

NO ¶

Landowner requests to convert grasslands to cropland after mining are likely, particularly when the market price of cereal grains is high compared to beef. Depending on the size of areas, these decisions reduce species such as sharp-tailed grouse which depend heavily on native prairie. Small areas of woodland and shrubland could also be affected by those decisions, but the topography of most major woody draws is too steep to make conversion to cropland economical.

Unless the landowner requests conversion of these steep areas to grassland, the Public Service Commission would require woodland and shrubland habitats restored to the extent practical (Klein 1978, personal communication). However, as explained in the Vegetation section, the effective restoration of woodland habitats has not yet been proven.

Locally and cumulatively, all the above land use changes could have a significant impact on both game and non-game wildlife.

Prairie Dog Increases Improve the Chances For Black-Footed Ferrets in the Seven County Study Area

At the time the Draft Study was written, available information indicated that prairie dogs were decreasing within the seven county study area. However, a recent report by Seabloom et al. (1978) reveals that the opposite is true, apparently because of the halt of government prairie dog control efforts. The return of the prairie dog indicates a growing opportunity for the increase of the black-footed ferret.

To reflect this, the last full paragraph of column 3; and the quotation that spans columns 3 and 4 on page 51, should be replaced with the following:

> There has been a noticeable increase in prairie dog towns in southwest North Dakota, and elsewhere in the western portion of the state, over the last 8 10 years (Seabloom et al. 1978). This increase in prairie dog towns indicates greater opportunity for the increase of the black-footed ferret.

The increased possibility of ferrets occurring in the seven county study area increases only slightly the already mentioned remote chance that the proposed actions would impact this endangered species. However, in order to reflect this slight change in the analysis, paragraph 2, column 1 on page 111 should be replaced with the following:

> Ferret observations and sign within the seven county study area in the last 60 years has been confined to Mercer, Dunn, Burleigh, and, particularly, Morton County (Linder and Hillman 1973). Most observations since 1970 were made at sites with prairie dog towns at least within a 2-mile radius. Based on available data, including an absence of prairie dog towns, it is probable that ferrets may no longer occur in Oliver and Mercer Counties, the two counties which ~~will~~ would host the most development under Level 1. Although Level 1 mining and construction may not directly affect any known prairie dog towns, increased disturbance (particularly shooting) related to the increase in human populations~~,~~ could reduce the size of the prairie dog towns and, thus, indirectly affect any remaining ferrets.

Transmission Line Electrocution Hazard to Raptors

Discussions in several places in the Draft Study (page 110, column 1, paragraphs 7 and 8; page 111, column 1, paragraph 5; and page 174, column 3, 8th full paragraph) incorrectly assumed that all high voltage transmission lines present an electrocution hazard to raptors. Because of the distance between conductors, 69 kv lines and above are not an electrocution hazard to eagles and other raptors (Olendorffe 1978, personal communication). The only line that is part of the proposed action that could cause bird electrocutions is the 41.6 kv line from the NGPL plant to Lake Sakakawea. However, the applicant has committed to make this line "electrocution proof" for raptors.

Thus, bird losses would be expected only from smaller distribution lines. No estimate is available for the number of miles of smaller distribution lines which would be developed as a result of the proposed action.

The Northern Kit (or Swift) Fox is Not on The Federal Endangered Species List

Although the northern kit (or swift) fox--*Vulpes velox hebes*--is officially endangered in Canada and is observed occasionally in several northern states, including North Dakota, it is not officially an endangered species in the United States. References to this species in paragraph 7, column 3 and the first full paragraph in column 4, page 51, and paragraph 7, column 1, page 111 should be transferred to the discussion in paragraph 7, column 1, page 52, of additional species listed by the state of North Dakota.

Proposed Whooping Crane Critical Habitat

In the August 17, 1978, Federal Register, the U.S. Fish and Wildlife Service published proposed rulemaking that would establish critical habitat for the whooping crane in major portions of the seven county study area. Lake Ilo National Wildlife Refuge; all of Lake Sakakawea within maximum full pool, including the Audubon National Wildlife Refuge; and all of Oahe Reservoir within maximum full pool are proposed for critical habitat designation. If these areas are designated as critical habitat, there would be significant implications for the developments proposed under Levels 1 and 2. The proximity of the NGPL project to Lake Ilo would be of particular concern. Although it is premature at this date to predict what activities would be or would not be allowed within and near critical habitat, it seems clear that the NGPL project would reduce the attractiveness of the Lake Ilo Refuge to whooping cranes because of the increase in human population and possible noise and air pollution problems. Whether sufficient mitigating measures could be developed that would allow the project to proceed despite critical habitat designation would require further study.

It appears that as of October 31, 1978, it will be at least six months before any whooping crane critical habitat designations are finalized within the seven county study area. An Endangered Species Act Appropriation Bill and attached amendments also recently passed through Congress and are awaiting the President of the Senate's signature and the President's signature. When this appropriation act and attached amendments become law, it will establish new criteria for the designation of critical habitat. All critical habitat designations that have been proposed but not finalized must be proposed again under new criteria. It is not known if the proposed whooping crane critical habitat designations of the August 17, 1978, Federal Register will qualify for designation under the new criteria. If they do, it will take at least six months for the process, including the development of new regulations, to be completed.

Other Changes

Draft Study

Maps 2-23 through 2-34 should have the word "relative" eliminated from the title.

On Map 2-36, the solid and open circles representing verified and unverified prairie dog towns should all be the same size. The following confirmed black-footed ferret sightings (from Linder and Hillman 1973) should also be added:

County	Year	Location
Dunn	1913	Quinion (between Killdeer & Medora)
Mercer	1915	Stanton
Burleigh	1961	East of Bismarck
Morton	1968	Sec. 21, T. 137 N,. R. 80 W.
Morton	1971	Sec. 28, T. 135 N., R. 80 W.

On Map 3-24, the word "relative" should be removed from the last line of the note below the legend.

On Map 3-25, the parenthetical definitions of intermediate and low sensitivity should be interchanged.

On Map 3-27, the Lake Ilo and Audubon National Wildlife Refuges should be included. The note under the legend starting "(Wetland Areas) . . ." should be replaced with the following: "The only National Waterfowl Management Easements and National Waterfowl Production Areas in the seven county study area are in McLean and Burleigh Counties. The Audubon National Wildlife Refuge is on land owned by the Corps of Engineers, but is managed by the Fish and Wildlife Service through a cooperative agreement."

On page 48, column 1, the next to the last word should be eliminated so that the last part of the sentence reads ". . . the pheasant and Hungarian partridge have become established."

On page 48, column 3, paragraph 4; and page 62, column 3, paragraphs 7 and 8, scientific names should be italicized, and Yucca glanca should be spelled Yucca gla~~n~~uca.

On page 49, column 1, paragraph 3 should be replaced with the following:

> Although they lack the expanses of grassland characteristic of the very best sharp-tailed grouse habitat, most of Morton, Oliver, Mercer, and Dunn Counties have high sharptail populations compared to McLean and Burleigh Counties, only parts of which are rated high. Stark County is rated the lowest of the seven counties for sharptails (Map 2-26).

On page 50, column 1, paragraph 3, the first sentence should begin, "Important sandhill crane migration stopover sites. . ."

On page 51, column 3, paragraph 8, the following specie should be added to the list of endangered birds:

> "(Northern bald eagle - Haliaetus leucocephalus - declared officially endangered in the February 14, 1978, Federal Register)."

On page 52, column 1, paragraph 1 should be eliminated.

On page 52, column 4, the following paragraph should be added to the discussion of threatened and endangered species:

> The Endangered Species Act of 1973 was signed into law by the President on December 28, 1973. The Act is the strongest legislation ever enacted to preserve and protect endangered and threatened animals and plants. There are provisions for state cooperation and participation through cooperative agreements, grants-in-aid funding, and other incentives. The new Act calls for participation where appropriate by all federal agencies and directs that no federal funds can be utilized for an activity that would be detrimental to an endangered or threatened species. The effect of this Act on threatened and endangered species should be favorable, allowing maintenance and in some cases increases in their populations. Where habitat is protected or developed for endangered species, other species dependent upon that habitat will also benefit.

On page 108, column 1, paragraph 7, the last sentence should be changed from ". . . 700 miles of electric transmission lines . . ." to ". . . 424 miles of electric transmission lines . . .."

On page 108, column 3, 5th full paragraph, the first sentence should be replaced with the following: " The projected construction of 424 miles of new transmission lines would result in an increase in wire strike mortality for many species of birds."

On page 108, column 4, 5th full paragraph, the last sentence should be changed from "(metals) . . . can also affect selenium intake by animals . . ." to ". . . may be able to cause selenium deficiency in some animals . . ." The following sentence should also be added: "The potential significance of this problem in the seven county study area is unknown but is not believed to be great, because the disease is uncommon and can be effectively treated with vitamin E."

On page 109, column 3, the first full paragraph should be replaced with the following:

> The preferred habitats of antelope (grassland and shrubland) would be impacted most severely in the NGPL, ANG, and Antelope Valley project areas (Table 3-57 in the Vegetation section). It is likely that the losses would be measurable and might total 10-20 animals annually until successful reestablishment of rangeland is achieved. Antelope population densities (Map 2-3) are high in portions of the NGPL, ANG, Antelope Valley, and Glenharold Mine project areas. The probability of measurable impacts appears to be especially high in the vicinity of the ANG and Antelope Valley plants (Hostetter 1977, personal communication).

On page 109, the paragraph spanning columns 3 and 4 should be replaced with the following:

> Construction of transmission lines and product pipe lines associated with the proposed actions would disturb 110 acres of wetlands (Table 3-47 in the Vegetation section). Significant long-term impacts could result to these wetlands. Trenching or drilling in a clay-sealed wetland could break through the seal resulting in drainage. However, many of these wetlands are believed to be underlain by deep layers of impervious clay till which should provide protection from such

damage. In addition to damage or loss from drainage, wetlands could be detrimentally affected by improper spoil disposal and backfilling.

On page 109, column 4, the first full paragraph should be replaced with the following:

> The projected increase of 424 miles of new transmission lines (Table 1-8 and Map 1-6 in Chapter 1) plus an additional but unknown number of miles of new distribution lines would result in an increase in waterfowl mortality from wire strikes. Figure 3-8 shows this can be of local significance. Birds are certain to collide with wires where they cross natural flyways such as the Missouri River (Oahe Reservoir) near the mouth of the Cannonball River. The North Dakota Game and Fish Department indicates that peak mallard populations in that area are in the 8,000-10,000 range. In addition, bald eagles are often recorded in that area during the Winter Waterfowl Count. A minimum of several hundred waterfowl could be killed annually by the 424 miles of new transmission wires (Anderson 1978, Fish and Wildlife Service 1978, Krapu 1974, McEnroe 1972, McKenna and Allard 1976, and Weir 1972). Probably these several hundred birds by themselves would not significantly reduce waterfowl populations within the seven county area, but when added to losses from other causes they may be important.

On page 110, column 2, paragraph 1, the last two sentences should be combined as follows: ". . . regional non-game bird populations would not be significantly affected, and local populations would be restored to the extent reclamation of their habitats is successful. See Chapter 6 for a discussion of some of the difficulties of reestablishing wildlife habitats."

On page 110, column 4, paragraph 2, the second sentence should be replaced with: "There is not enough data available to quantify this impact."

On page 111, column 1, paragraph 9; and page 113, column 4, paragraph 1, should both have the following sentence added: "The discussion of air pollution impacts on page 108 applies to Fort Berthold as well as the rest of the seven-county study area."

On page 112, column 4, paragraph 2; and page 113, column 4, paragraph 3 should have references to the colors representing the three habitat ratings shown on Map 3-25 changed to: Habitats rated "1" being dark brown on the map, those rated "2" being an intermediate brown, and those rated "3" or "4" being light brown.

On page 113, column 1, paragraphs 1, 2, and 3 should have references to Map 3-23 in the Vegetation section changed to Map 2-20 in the Vegetation section.

On page 159, third column, the last full paragraphs should refer to Table 1-3 rather than Table 1-10.

On page 183, column 4, 4th full paragraph, the second sentence should include a parenthetical reference to Appendix 2.

Summary

On page 23, column 1, paragraph 2, the last sentence should be replaced with: Some non-game species especially tolerant of man, such as English sparrows, horned larks, and house mice, would increase in response to habitat modifications caused by a gradually increasing human population and its increasing influence on the environment.

On page 23, column 2, first full paragraph, the third sentence should have the parenthetical phrase ". . .(nominated for endangered status) . . ." eliminated.

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On page 64, paragraph 1 should be replaced with the following: Residual impacts would be similar to impacts without mitigation. Air pollution and increased numbers of non-Indian visitors to the reservation could reduce animal populations, but it is not likely that the impacts would be measurable.

On page 64, paragraph 2 should be replaced with the following: The proposed actions would not affect the productivity of wildlife and domestic animals beyond the life of the projects. Future management options of the Three Affiliated Tribes with respect to domestic animals and wildlife would not be affected.

On page 64, paragraph 4, the first line should have the word "populations" replaced with the word "impacts."

References

The following references are cited in this Final Supplement but not in the Draft Study:

Anderson, W.L. 1978. Waterfowl collisions with power lines at a coal-fired power plant. Wildlife Society Bulletin, Vol. 6, No. 2, pp. 77-83.

Fish and Wildlife service 1978. Office files, Bismarck Area Office.

Kaiser, Robert 1978. Personal communication (Assistant Project Manager).

Krapu, G. 1974. Avian mortality from collisions with overhead wires in North Dakota. The Prairie Naturalist, Vol. 6, No. 1, pp. 1-6.

McEnroe, M. 1972. Summer Employment Report, Audubon National Wildlife Refuge, Coleharbor. June 5-August 25, 1972.

McKenna, M.G. and G.E. Allard 1976. Avian mortality from wire collisions. North Dakot Outdoors, Vol. XXXIX, No. 5, pp. 16-18.

Olendorffe, Richard R. 1978. Personal communication. Telephone conversation August 17, 1978. (Biologist, U.S. Bureau of Land Management, California State Office, Sacramento).

Seabloom, R.W., R.D. Crawford and M.G. McKenna 1978. Vertebrates of southwest North Dakota - amphibians, reptiles, birds, mammals. Research Report #24, Institute for Ecological Studies, University of North Dakota, Grand Forks, 549 pp.

Weier, R. Wayne 1972. A probable instance of songbird mortality. The Prairie Naturalist, Vol. 4, No. 2, pp. 55-56.

PREHISTORIC AND HISTORIC FEATURES

MODIFICATIONS AND CORRECTIONS

Description of the Environment (Chapter 2)

Comments from the State Historical Society of North Dakota indicated concern about the need for updated data. New and important cultural resources information has been developed since the Draft Study was completed. A summer and fall, 1977, inventory was conducted on the mine areas proposed for the ANG Coal Gasification Plant and Antelope Valley Power Plant in Mercer County. A total of 27,721 acres of the proposed mine area and railroad spur in six townships were intensively inventoried. A March 1978 report (Dill 1978) detailed the location of 149 prehistoric and historic sites (14 of which had been reported earlier by other investigators). For the total 149 sites known as of September 1, 1978, categorization of the sites is shown in Table 1.

Table 1
Prehistoric and Historic Features Associated With
ANG Coal Gasification Plant and
Antelope Valley Power Plant

Prehistoric	
Stone Circle Sites	94
Lithic Scatters	10
Rock Cairns	1
Subtotal	105
Historic	
Farmsteads	37
Schools	2
Trails	1
Coal Mines	1
Cemeteries	3
Subtotal	44
TOTAL	149

Map 1 shows the exact area inventoried. The inventory area encompasses portions of the proposed Federal Coal Study Areas S-1, N-1A, N-2A, and N-2B. The increased amount of inventory requires several changes in Draft Study Chapter 2 tables and maps. In Table 2-40, site category totals would change for Mercer County and in the totals column as follows:

	MERCER COUNTY		TOTAL	
	From	To	From	To
Stone Circles	25	119	54	148
Lithic Scatters	3	13	144	154
Cairns	5	6	27	28

On Map 2-37, parts of the enclosed dashed lines north of Beulah indicating spot-checking for prehistoric and historic features have now been intensively inventoried. Those portions can be determined by using the township and range mylar overlay in the Draft Study with Map 2-37, while referring to Map 1 in this document. (Also on Map 2-37, Cairns is misspelled, and the legend blocks should be red.)

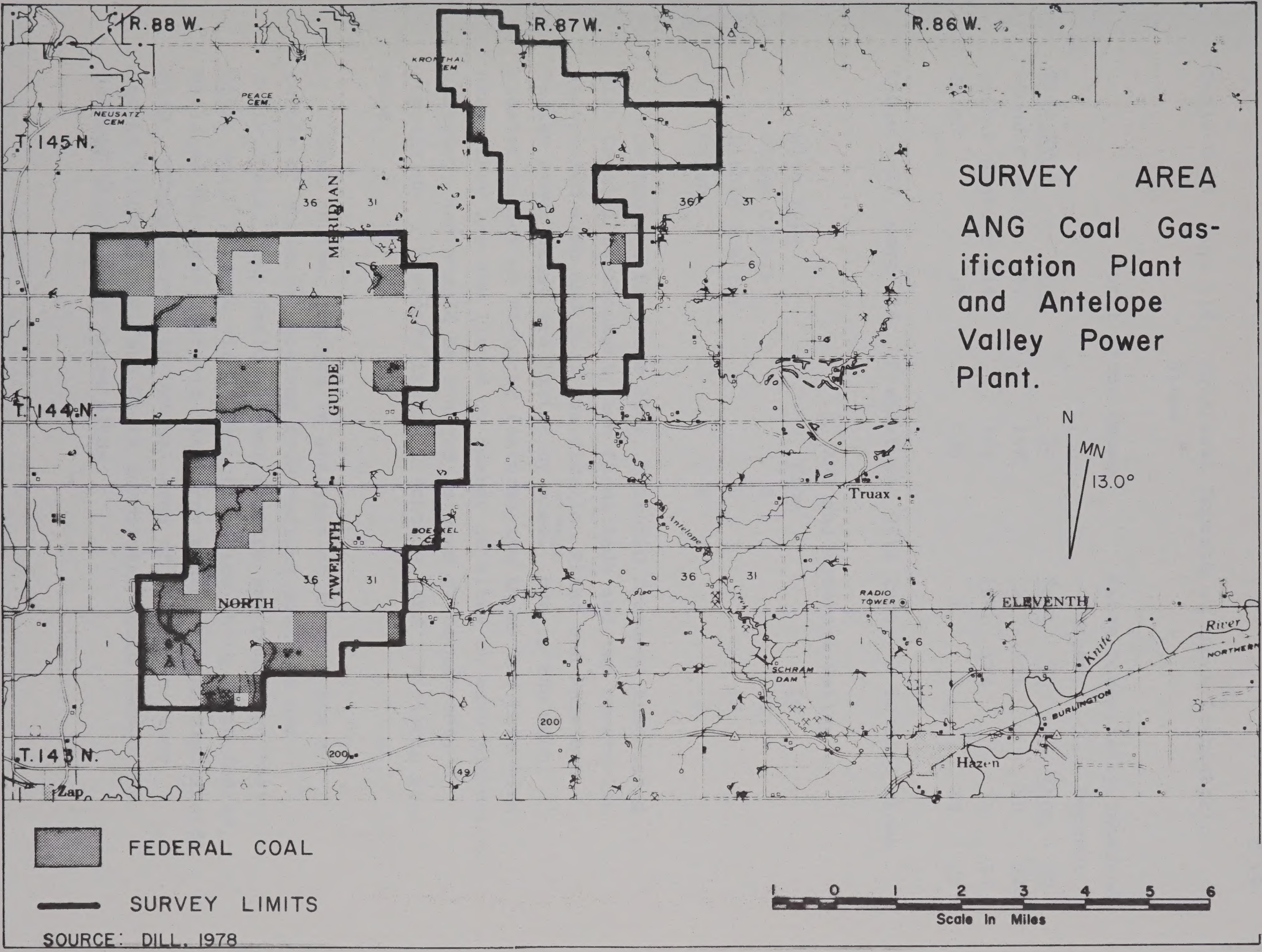
Other Chapter 2 Changes

On page 53, column 1, paragraph 4, line 10, "ever" should read "even."

On page 54, column 3, paragraph 1, line 6, "Tracts N-1A and N-1B have not been inventoried" should be deleted.

Environmental Impacts (Chapter 3)

The 149 sites listed above could be impacted and potentially destroyed by mining and ancillary construction. The importance of the potential loss of these sites cannot be determined at this time because they have only been surface~~d~~-recorded. The report on the inventory (Dill 1978) recommends further study to determine their importance. Table changes in Chapter 3 required by the new information are as follows:



R. 88 W.
R. 87 W.
R. 86 W.
T. 145 N.
T. 144 N.
T. 143 N.
KRONTHAL CEM
PEACE CEM.
NEUSATZ CEM
MERIDIAN
GUIDE
TWELFTH
NORTH
ELEVENTH
BOECKEL CEM
Truax
Antelope Creek
RADIO TOWER
SCHRAM DAM
Knife River
NORTHERN
BURLINGTON
Hazen
Zap
200
49
36
31
1
6
N
MN
13.0°
0
1
2
3
4
5
6
Scale In Miles

SURVEY AREA

ANG Coal Gasification Plant and Antelope Valley Power Plant.

▨ FEDERAL COAL

▬ SURVEY LIMITS

SOURCE: DILL, 1978

Table 3-79, page 114. Potential Impacts on Known Prehistoric Sites

	Total Sites Known		Sites Potentially Impacted			
			Number		Percent	
Site Type	From	To	From	To	From	To
Stone Circle	54	148	27	121	50	82
Lithic Scatter	144	154	104	114	72	74
Cairn	27	28	6	7	22	25

Table 3-80, page 114. Prehistoric Site Types in Level 1 Areas

	ANG and Antelope Valley	
Site Type	From	To
Stone Circle	5	94
Lithic Scatter	0	10
Cairn	0	1

On Table 3-81 (page 115), Historic Features Associated With Level 1 Development, two farmsteads and two cemeteries associated with ANG Coal Gasification Plant and Antelope Valley Power Plant are listed by ~~mine.~~ name. Due to the much greater number of historic features now known for this mine area, they are now listed by number of sites on each historical category, and should be changed to read 37 farmsteads, 3 cemeteries, 1 historic trail, 2 schools, and 1 historic coal mine.

Some further changes in analysis of impacts are a result of comments received from various agencies and individuals. The National Park Service was concerned that there would be some visual impacts on the Knife River Indian Villages National Historic Site from mining at the Glenharold Mine. Mining within the visual area of the Knife River Indian Villages and Fort Clark downstream would change the natural setting for these sites.

Further discussion of the evaluation of prehistoric and historic sites, a concern of the State Historical Society of North Dakota, is needed to clarify the treatment in the impacts chapter, but also in other chapters and the appendix. Two areas need to be stressed. First, simply recording that a site exists does not evaluate it. For historic sites, documentation is necessary. Test excavation is often, but not always, necessary to evaluate the importance of prehistoric sites. Second, the inferrence should not be made from the Draft Study that the many sites recorded (with little supporting evaluatory information) are unimportant. Most of the approximately 550 prehistoric sites and numerous historic sites presently known have not been fully evaluated.

Other Chapter 3 Changes

On page 114, column 2, paragraph 1, line 3, the "plant" area should read "study" area.

On page 114, column 2, paragraph 3, line 10, the sentence beginning "The Quarries . . ." should begin "Five of the quarries and six of the lithic scatters . . ."

On page 115, Table 3-81, Wodworth should read Woolworth.

Mitigating or Enhancing Measures (Chapter 4)

Under Additional Enforceable Measures on page 160, column 2, of the Draft Study, the new information from ANG Coal Gasification Plant and Antelope Valley Power Plant causes the following changes:

Paragraph 2, item 2 calls for a supplementary report on ANG. Such a report is now complete (Dill 1978). Item 3.c should be amended to require further evaluation and possible avoidance and/or excavation of 105 prehistoric features; and further evaluation and/or preservation of 44 historic sites.

Since completion of the Draft Study, more information relating to the recommendation of a potential National Register of Historic Places District on or near the proposed NGPL development is available and should answer the concerns of NGPL mentioned in their comments. The extensive survey in Mercer County on the ANG Coal Gasification Plant and Antelope Valley Power Plant shows that of 105 prehistoric sites inventoried, only 10 are lithic scatters and no quarry areas were found. The distribution of sites on the NGPL study area shows 114 of 119 sites inventoried to be either lithic scatters or Knife River Flint quarries. This would suggest the lithic scatters to be important in the interpretation of the quarries. However, thus far the potential boundaries of such a district encompassing Knife River Flint quarries and lithic scatters depends upon inventory within coal study areas. It is suggested as an "Other Possible Measure" that this inventory be expanded to the northeast and south of the present NGPL study area to more meaningfully define the district. This inventory would be the responsibility of federal and state agencies instead of energy companies because it would cover areas where no coal development is presently planned.

Residual Adverse Impacts (Chapter 5)

Further study of the 149 new sites inventoried on the proposed mine area serving ANG Coal Gasification Plant and Antelope Valley Power Plant would have similar effects in terms of residual adverse impacts to those already described in the study. New information would be added to the prehistoric and historic record, but information would be lost from portions of sites not excavated or preserved. Also the sites could not be restudied with improved future research methods.

References Cited

The State Historical Society of North Dakota commented on omission of sources for Table 2-39. The source for Table 2-39 should read as follows: Dill 1975a, 1975b, 1976a, 1976b, 1977; Fox, Stolt, and Loendorf 1976; Loendorf, Carmichael, and Miller 1976; and Woolworth Research Associates 1974. Of these sources, only Dill 1977; Loendorf, Carmichael, and Miller 1976; and Woolworth Research Associates 1974 are presently listed in the References Cited section.

The following references should be added:

Dill, C.L. 1975a. 1975 archaeological and historic sites survey of the Falkirk Mining Company extended mining plan areas, McLean County, North Dakota. Manuscript on file, State Historical Society of North Dakota.

_____1975b. Archaeological and historic sites survey, South Beulah Mine and Gascoyne Mine expansion areas, Knife River Coal Company. Manuscript on file, State Historical Society of North Dakota.

_____1976a. 1976 Archaeological and historical sites survey of the North Americal Coal Corporation's Indianhead Mine, limited and extended mining plan areas, Mercer County, North Dakota. Manuscript on file, State Historical Society of North Dakota.

_____1976b. 1976 archaeological and historic sites survey of the Baukol-Noonan, Incorporated, Center Mine limited and extended mining plan areas, Oliver County, North Dakota. Manuscript on file, State Historical Society of North Dakota.

Fox, Richard; Wilbur Stolt; and Lawrence Loendorf 1976. Archaeological and historical studies in the vicinity of the proposed Coyote Station electrical generation plant site near Beulah, North Dakota. Research Report No. 16, Institute for Ecological Studies, University of North Dakota, Grand Forks.

One further reference should be added to the References Cited section based on the information obtained in connection with the ANG Coal Gasification Plant and Antelope Valley Power Plant proposals:

Dill, C.L. 1978. 1977 cultural resources inventory; Antelope Valley Station/ANG Coal Gasification Plant site, associated mining areas, and ancillary facilities. Two volumes, manuscript on file at State Historic Society of North Dakota.

AESTHETICS

INTRODUCTION

Only three comments were received on the Aesthetics analysis. Minor revisions were made in text items; however, no changes resulted in significant modifications to conclusions or analysis results.

MODIFICATIONS AND CORRECTIONS

Draft Study

On page 55, column 2, line 10, "(good)" should be changed to "(average)".

On page 56, column 2, "intersity" should be changed to "intensity."

On page 205, Lee Huber should be added to the list of participants from the North Dakota State Health Department.

The title of Map 2-39 (Regional Analysis) should be changed to Scenery Units and Visual Sensitivity Zones. The legend should include a heading Scenery Units above the word "Plains" and a heading Visual Sensitivity Zones after the legend line "Major Lakes in the Prairie Potholes Plains."

No ¶ Items 1 and 2 of the legend should read "Missouri River Valley" and "Major Lakes West of Missouri River."

Site 150 on Map 2-42 should be changed to show it as a Federal Recreation Area rather than as Potential State Nature Preserve. The legend should be changed accordingly.

RECREATION

INTRODUCTION

Most of the comments on the recreation analysis dealt with impacts to the Fort Berthold Indian Reservation and came from representatives of the Three Affiliated Tribes. The primary emphasis of the comments was on jurisdictional issues and the need to provide additional information on tribal planning efforts. Discussions of the jurisdictional issue relative to recreation were for the most part already included in the Draft Study, but additional information is provided on tribal proposals for the Lake Sakakawea shoreline.

NO ¶ Other comments dealt with minor technical changes or additions.

MODIFICATIONS AND CORRECTIONS

Draft Study

On Map 2-42, the following historic sites have been added:

County	Site Name	Legal Description
Mercer	Fort Clark Historic Site	Section 36, T. 144 N., R. 84 W.
Burleigh	Double Ditch Historic Site	Section 21, T. 140 N., R. 81 W.
Burleigh	Menoken Indian Village Historic Site	Section 22, T. 139 N., R. 78 W.
Mercer	Crowley Flint Quarry Historic Site	Section 1, T. 142 N., R. 90 W.
Dunn	Killdeer Mountains Battlefield Historic Site	Section 33, T. 146 N., R. 96 W.
Morton	Huff Indian Village Historic Site	Section 8, T. 136 N., R. 79 W.
Burleigh	Chaska Historic Site	Section 34, T. 140 N., R. 75 W.
Burleigh	Steamboat Warehouse Historic Site	Section 31, T. 139 N., R. 80 W. (in Bismarck)
Burleigh	Camp Hancock Historic Site	Section 4, T. 138 N., R. 80 W. (in Bismarck)
McLean	Fort Mandan Historic Site	Section 15, T. 144 N., R. 84 W.

(Location in Draft Study correct for McLean County Historic Site of same name)

On Map 3-30, two legend items are reversed. Recreation Resources Physically Disturbed by Level 1 Projects should be shown in the legend as dark areas. Additional Use Zones should be shown in the legend as light grey areas.

On Map 3-32, the legend should be clarified as follows:
grey ▱ Level 3
High
Moderate

The last two sentences of paragraph four, column one, on page 176 should be revised to read as follows:

> Adequate tax revenues needed to build new facilities would not be available even with the increase in population. North Dakota Coal Impact Office funds would be available from existing coal production through coal severance tax collections.

Summary

The fourth sentence in column 2, page 33, should be reworded as follows:

> State law and subsequent regulations forbid energy conversion facility siting on federal, state, or local recreation areas, wildlife refuges, game management areas, hardwood draws, or unique natural areas. In addition, transmission facility siting is restricted in federal or state parks, historic sites, monuments, landmarks, national wilderness areas, state archaeological sites, state nature preserves, and all local park and recreation areas.

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On page 77, the heading "Natural Values" should be changed to "General Recreation Values."

On page 77, the first sentence in the last paragraph on page 77 should be deleted.

On page 77, the last sentence should read as follows: "The Three Affiliated Tribes have proposed tribal administration for seven major areas along the shores of Lake Sakakawea to be managed as conservation and wildlife habitat areas."

On page 85, the last paragraph ~~on page 85~~ should be deleted.

ECONOMIC CONDITIONS

INTRODUCTION

Comments on the economic conditions ~~section of~~ is the Draft Study were received from state, industry, and private sources within North Dakota.

Many of the comments, from private individuals in particular, expressed a desire for more complete information concerning boom-bust cycles, probability of future development, and impacts from coincident oil and gas development. In most cases, it could only be explained that inherent uncertainties preclude any further analysis on boom-bust cycles or future development beyond that already analyzed in Levels 1, 2, and 3. In other cases (concerning oil and gas development in Stark and Dunn Counties, for example), additional information not previously available is now included.

The North Dakota Regional Environmental Assessment Program (REAP) questioned some inconsistencies in income, population, and employment projections. These subjects were updated with more current information.

Changes were also made because of industrial concerns regarding current and future levels of coal severance revenues available to the state for impact assistance.

MODIFICATIONS AND CORRECTIONS

Draft Study

Even though the economic modeling indicated that the additional Level 2 development would not significantly impact Stark County, future coal development coincident with future large scale oil and gas development could conceivably

generate significant social and economic impacts in Dickinson and Killdeer, as well as in the general area. However, indications so far are that oil and gas development in Dickinson has not created significant impacts on that community's infrastructure. According to Mayor Schank, there were some seismograph people in the area earlier in the year, most of whom have left. The mayor estimates that there are only approximately 30 to 40 new families (maximum) in Dickinson directly related to oil and gas activity.

Mayor Binnick of Killdeer feels that impacts from oil and gas activity are noticeable in that community. Housing seems to be the most highly impacted sector. Recent building includes two new motels, a six-plex, two four-plexes, two or three duplexes, and 10 to 15 new single family residences. In addition, he feels that a new trailer court is needed. There is only one cafe open in town; the other two are closed due to health restrictions. The water and sewage treatment capacity of the town could handle double the present population as a result of a new well and remodeling of the sewage treatment lagoon.

It is uncertain at this time how much additional oil and gas related impacts will occur in this area. Mayor Schank noted that seismic activity in the Dickinson area resulted in the most noticeable increase in people. The actual manpower requirements for development and operations were not large due to the high degree of mechanization and automation present in modern day oil fields.

~~Also see responses #36 and #72~~

The "total" column in Table 2-46 should read "Total State."

Table 2-52 should include an entry of "198" for Butte in 1975.

Revised Table 2-60 entries are ~~presented below:~~ as follows:

	Burleigh	Dunn	McLean	Mercer	Morton	Oliver	Stark	7 County Total
1978	19,818	1,628	4,264	2,666	7,408	1,036	8,151	44,971
1979	20,172	1,613	4,163	2,612	7,385	1,028	8,252	45,225
1980	20,440	1,600	3,945	2,530	7,333	1,013	8,349	45,210
1981	20,982	1,589	3,964	2,536	7,364	1,015	8,467	45,917
1982	21,485	1,579	3,097	2,526	7,380	1,014	8,578	45,659
1983	21,987	1,567	3,857	2,513	7,391	1,014	8,686	47,015
1984	22,491	1,554	3,802	2,503	7,398	1,011	8,790	47,549
1985	22,997	1,541	3,750	2,491	7,402	1,099	8,891	48,141
1986	23,501	1,529	3,698	2,478	7,402	1,008	8,991	48,607
1987	24,008	1,517	3,644	2,466	7,398	1,006	9,088	49,127
1988	24,512	1,504	3,592	2,452	7,390	1,004	9,182	49,636
1989	25,018	1,490	3,537	2,438	7,381	1,002	9,271	50,137
1990	25,525	1,478	3,486	2,428	7,368	1,000	9,358	50,643
1991	26,029	1,463	3,433	2,413	7,351	998	9,440	51,127
1992	26,535	1,450	3,381	2,399	7,333	995	9,521	51,614
1993	27,041	1,436	3,332	2,387	7,310	991	9,598	52,095
1994	27,554	1,422	3,278	2,372	7,285	989	9,673	52,573
1995	28,047	1,408	3,230	2,356	7,258	986	9,742	53,027
1996	28,548	1,395	3,179	2,341	7,229	983	9,807	53,482
1997	29,048	1,380	3,130	2,326	7,196	980	9,872	53,932
1998	29,548	1,366	3,082	2,312	7,162	977	9,935	54,382
1999	30,047	1,352	3,032	2,295	7,125	973	9,996	54,820

Revised Table 2-61 entries are shown below:

Year	Burleigh	Dunn	McLean	Mercer	Morton	Oliver	Stark
1980	45.2	3.5	8.7	5.6	16.2	2.2	18.5
1990	50.4	2.9	6.9	4.8	14.5	2.0	18.5
1999	54.8	2.5	5.5	4.2	13.0	1.8	18.2

Revised Table 2-63 entries are shown below:

Year	Per Capita Income
1975	$4,520
1976	4,876
1977	4,916
1978	4,913
1979	4,975
1980	4,980
1981	5,106
1982	5,206
1983	5,300
1984	5,392
1989	5,799
1994	6,158
1999	6,558

Revised Table 2-64 entries are shown below:

Year	Personal Income
1975	$626,090
1976	677,268
1977	690,097
1978	697,512
1979	712,476
1980	719,326
1981	745,704
1982	768,121

1983	790,537
1984	812,954
1989	925,036
1994	1,307,118
1999	1,149,200

Revised Table 2-65 entries are shown below:

Year	Business Activity
1975	923,755
1976	998,550
1977	1,019,273
1978	1,030,454
1979	1,048,214
1980	1,055,322
1981	1,091,436
1982	1,123,579
1983	1,155,721
1984	1,187,861
1989	1,348,566
1994	1,509,269
1999	1,669,974

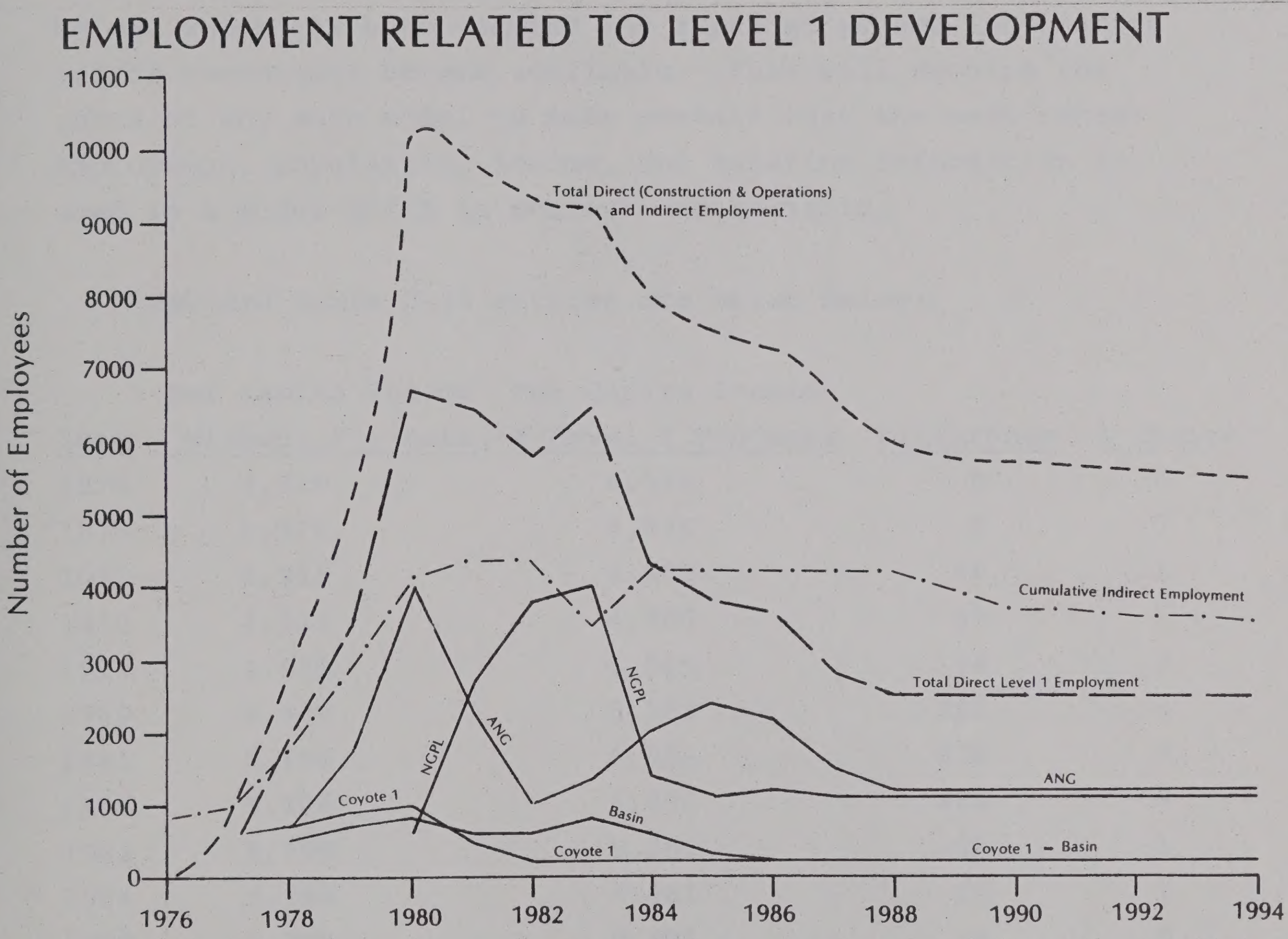
The footnote in Table 2-69 should read ". . .6/30/79" instead of ". . .6/30/78."

On page 125, ~~of the Draft Study,~~ the following clarifier should be added at the bottom of column one:

> The economic modeling used to predict future economic and social conditions in communities in the seven county study area looked only at incorporated communities. It is likely that some unincorporated communities in the study area could also experience economic growth as a result of future energy development. The modeling procedure used is discussed in greater detail in the Economic and Social Conditions Technical Supplement.

Sector rows in Table 3-91 should be numbered 1 through 13. The next to the last parenthetical statement on page 126 should read: "(sectors 3 through 11 of Table 3-91)."

Figure 3-27 is revised as shown below:



Note: 1980 ANG Coal Gasification Co. includes 1680 pipeline jobs outside of seven county study area. Mine employment includes conversion facility employment.

SOURCE: Direct employment estimates by industry. Indirect employment estimates by North Dakota Regional Environmental Assessment Program, 1977.

Chapter 4 (Mitigating Measures) should mention that economic impact assessment methodology and the relevancy and accuracy of data should be monitored. If this monitoring is done, it is likely that future modeling efforts would benefit from any refinements in data collection and projection techniques. As the modeling becomes more accurate through these improvements, the response to forecasted impacts by legislators and decisionmakers would also become more effective and useful.

As an example, the 1978 update and expansion of the North Dakota Regional Environmental Assessment Program (REAP) model will provide North Dakota legislators with more accurate information upon which to base decisions concerning the economic future of the state. It is suggested that any economic assessment model which is used by decisionmakers be one which has been updated and expanded as new information and/or techniques become available. This will require the users of any such model to make certain that the most recent employment, population, income, and taxation information is used in a model which is current and reliable.

Revised Table 3-93 entries are shown below:

Year	Per Capita Income Without Projects	Per Capita Income W/Level 1 Projects	Difference	% Change
1975	4,520	4,520	0	0
1976	4,876	4,876	0	0
1977	4,916	4,982	66	1
1978	4,913	4,980	67	1
1979	4,975	5,069	94	2
1980	4,980	5,362	382	8
1981	5,106	5,556	450	9
1982	5,206	5,630	424	8
1983	5,300	5,265	-35	-1
1984	5,392	5,461	69	1
1989	5,799	5,793	-6	0
1994	6,158	6,122	-36	-1
1999	6,558	5,484	74	1

The third column heading in Table 3-93 should read ". . . with Level 1 Projects" instead of ". . . with Level 2 Projects."

Revised Table 3-101 entries appear below:

Year	Per Capita Income Without Projects	Per Capita Income W/Level 2 Projects	Difference	% Change
1975	4,520	4,520	0	0
1976	4,876	4,876	0	0
1977	4,916	4,982	66	1
1978	4,913	4,980	67	1
1979	4,975	5,069	94	2
1980	4,980	5,362	382	8
1981	5,106	5,596	490	10
1982	5,206	5,648	442	8
1983	5,300	6,245	945	18
1984	5,392	5,526	134	2
1989	5,799	5,774	-25	0
1994	6,158	6,097	-61	-1
1999	6,558	6,448	-110	-2

Summary

The first money bag in Figure 23 for Level 1 and Level 2 should be 285 instead of 385. The last money bag in Level 1 should be 1892 instead of 2445. The ~~lL~~last money bag in Level 2 should be 3,501 instead of 5,319.

SOCIAL CONDITIONS

INTRODUCTION

Comments on the Social Conditions section of the Draft Study were received from academic, state government, and conservation group sources. The geographical locations of the academically-based commentators are outside the state of North Dakota, while state agency and conservation organization reviewers are located in North Dakota.

The university personnel who prepared statements differed in their orientations. The focus of one set of comments was ON the attitudinal study. The methods used in completing the research (the fundings of which are displayed in Chapter 2, Social Conditions) were questioned and severely criticized. These comments, incorporated indirectly in the testimony and directly in the written remarks of a conservation group representative, are based on the belief that relatively unstructured, ethnographic research is more valuable than structured social research. The response herein reiterated the assertion that reliability is enhanced through structure, that the scholarly reputation of the researcher is quite sound, and that attitudinal, not behavioral, analyses were judged most appropriate for the "existing environment" section of the Draft Study.

The second series of comments from another person in an academic setting are generally directed toward the impact-mitigation sections (Chapters 3-5) of the Draft Study. While generally complimentary, these perceptive and well-documented remarks indicate that some aspects of the analysis required simple elaboration or clarification, but no changes were required.

One state agency representative attached a series of articles and speeches for use by the study team. One dealt with the relationship between human pathology and social environment, another with a mental health specialists' experiences in Gillette, Wyoming, and another with rural industrialization and its social-demographic effects. A fourth attachment was an overview of social and economic issues associated with coal development. These documents reinforced the analysts' ideas on the severity of the social impacts anticipated. The conclusion of these reports, though much more elaborately stated, are consistent with the conclusions of the original assessment.

A major concern expressed through a state government representative, a conservation group member, and others, was the effects of air quality deterioration on human health. Several sources stated that the Social Conditions section of the Draft Study failed to adequately address this issue. ~~The response to these remarks~~ Such information is now located in Part 1, Climate and Air Quality.

A final series of comments, both written and oral, were received from a conservation group member who severely criticized the attitudinal study. These concerns were focused on the planning, execution, analysis, reporting, and application of the research. Part 2 reiterates the rationale behind the research, the strengths of the chosen approach relative to other methods, and asserts that the research was conducted by a respected, locally experienced, and skilled social analyst.

MODIFICATIONS AND CORRECTIONS

Draft Study

The second sentence under Social Conditions on page 136 should read: Population growth, particularly in Beulah, Hazen, and Killdeer, would be so rapid that dramatic changes in social conditions would be inevitable and, at least temporarily, chaotic and uncertain.

The third sentence under the Family on page 136 should read: However, expanded coal development would likely cause some of this socialization to be transferred from traditional structures, such as the family, to non-traditional groups, such as the schools, social service agencies, and emergent reference groups.

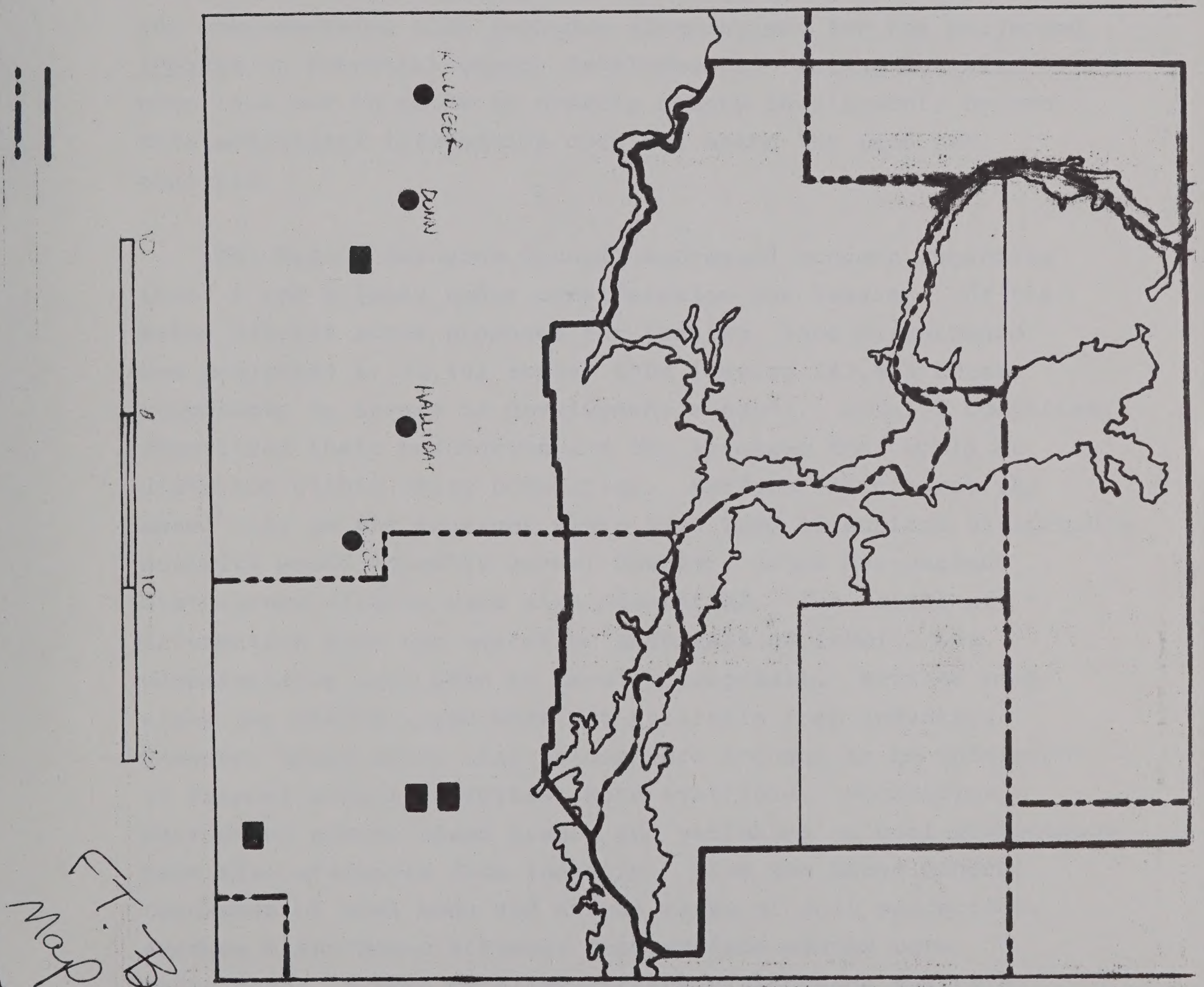
References should be amended to include the following:

Schneider, Don 1977. Personal interview, Gillette, Wyoming.

Weisz, Robert 1977. Personal interview, Gillette, Wyoming.

Revised Map 2-45 follows:

254 A


KILLDEER
DUNN
HALLIDAY
0
0
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20

Map

FT. Bert.
Map being
completed
for response
#137

LAND USE

INTRODUCTION

The Ro~~s~~osevelt-Custer Regional Council for Development has pointed out that Dunn County adopted county zoning ordinances and a comprehensive land use plan on December 6, 1977. As a result of extensive planning and public input, the comprehensive plan includes alternatives for the projected impacts of potential energy developments. Zoning has also been laid out to guide an orderly county development; however, this additional information does not amend the land use analysis.

The Dakota Resource Council expressed concern regarding Level 1 and 2 lands under consideration for leasing. Of the total 336,134 acres proposed for leasing, land disturbance was projected at 92,461 acres, thus leaving 243,673 acres supposedly in excess of development's needs. Level 1 companies identified their boundaries and the acreages that would be disturbed within those boundaries. Surface disturbance was based only on the acreages where some type of surface disturbance activity would actually occur; however, other non-surface disturbance effects were also identified. The detail of information from the tentative proposals of Level 2 was substantially less than in Level 1 proposals. Neither mine sites nor mining plans were yet available from industry. However, areas where coal values were thought to be sufficient to support mining activities were available. Boundaries were drawn around these areas, and estimates on coal productions were also available from industry. From the known general thickness of coal beds and annual rates of coal production, surface disturbance acreages from surface mining were calculated. A less detailed surface disturbance analysis was then made for those areas knowing only that mining would

likely occur somewhere within the boundary. Since no other surface disturbance activities have been identified within those boundaries, it was assumed that other disturbance would be equivalent to area disturbance within any mining proposal.

The Dakota Resource Council representative also expressed concern over rights of surface landowners who do not control mineral rights under their surface lands. The North Dakota Public Service Commission (PSC) can not issue a permit to surface-mine land unless the application is accompanied by statements of consent, executed by each surface owner within the permit area, to have surface mining conducted on his land. However, if surface owner consent cannot be obtained, district courts can authorize the PSC to issue the mining permit without the surface owner's consent. To issue this order, the court must be satisfied that the surface owner will be adequately compensated for lost production, lost land value, and loss of the value of improvements due to the mining activity. Also, the Secretary of the Interior cannot enter into any lease of federal coal until the surface owner has given written consent to enter and commence surface mining operations. The surface landowner whose land is proposed for lease must be consulted with to state his preference for or against offering such federal coal for lease. In those areas where a significant number of surface owners have stated a preference against the offering of the coal for lease, the Secretary shall, in his discretion, but to the maximum extent possible, refrain from leasing coal for development by methods other than underground techniques. Persons who are or who may be adversely affected by surface mining can petition the regulatory authority to have the land in question designated as unsuitable for all or certain

types of surface mining. A survey of the surface which has been leased over coal within five of the seven counties of the study area indicates that an average of 60% of the surface has been leased.

Another primary concern expressed by the Dakota Resource Council was the failure of the Draft Study to assess the impacts after the proposed projects end. It was reiterated that the environmental conditions after projects are terminated was discussed throughout the Draft Study under each environmental component. Chapters 5, 6, and 7 particularly address these issues. Detailed treatment of this subject, however, would be highly speculative. Because of the uncertainty surrounding the timing and magnitude of future energy and economic development beyond Level 2, it is impossible at this time to forecast the magnitude or timing of any possible turndown in economic activity.

A representative of the Dakota Resource Council noted that "a permit had already been granted for the (American Natural Gas coal gasification plant and Antelope Valley Power Plant) site on land containing 535 acres of prime farmland." Concern was expressed as to the status of prime farmland in the facility siting permit decision process. At the time of the writing of the Draft Study, North Dakota regulations did place prime farmland into the exclusion criteria for siting of energy conversion plants. Those regulations were revised in February 1978 to add the provision that exclusion would not apply to involved blocks of prime farmland of such small acreage as to be of negligible impact on agricultural production. The American Natural Gas application involved soils with small, isolated prime farmland acreages.

The Dakota Resource Council noted that mileage distances and impact analyses were based on a straight line between origin and termination of lines involved in energy development. A check with the companies shows that the Coyote

project transmission line mileage would not change and the Antelope Valley project transmission line mileage should increase over the straight line mileage by only about 4%.

Concern regarding consideration of Fort Berthold Reservation jurisdictions and land use impacts was expressed by the Three Affiliated Tribes. Work groups included a representative from the Fort Berthold Reservation, the North Dakota Indian Affairs Commission, and the Bureau of Indian Affairs. All reservation information was based on data provided by those representatives. They also prepared a technical supplement which provides a detailed treatment of impacts to the recreation resources of the Fort Berthold Reservation.

The concern expressed by the Dakota Resource Council regarding reclamation to 100% of pre-mining productivity within 3 to 5 years is discussed in the vegetation section.

MODIFICATIONS AND CORRECTIONS

Draft Study

On page 77, column 4, Counties, paragraph 5, replace the next to last sentence with:

> "As a result of extensive planning with much public input, Dunn County adopted county zoning ordinances and a comprehensive land use plan on December 6, 1977. The comprehensive plan includes alternatives which take into account the projected impacts of potential energy developments. Zoning also has been laid out to guide an orderly county development."

On page 166, column 3, Applicants' Commitments item 4, lines 4 and 5 should read:

> "Under the siting criteria, irrigated land and prime farm land (except in such small acreage as to be of negligible impact on agricultural production) are exclusion areas."

The proposed gas pipeline in Map 2-49 is mistakenly represented in blue as a 30-inch proposed water pipeline. The pipeline should be gold and would connect with the proposed Northern Border Pipeline, which should also be shown.

Map 2-51, Subsurface Ownership, will be reprinted and available at a later date. Meetings between state agencies, BLM, and printers are currently still planning how the map can be revised to be of maximum benefit in the future.

ALTERNATIVES

MODIFICATIONS AND CORRECTIONS

Draft Study

"Million" should be "billion" on line 2, paragraph 4, column 3, page 202.

Summary

Under the Coal Export alternative on page 47, the first sentence should be revised to read:

> A large amount of the coal currently mined in the seven-county study area is connected to electrical energy within the area and is then exported by transmission lines for use outside the state.

REFERENCES

Add as an introductory line: "Authors and work groups are found in Chapter 9 and are not listed herein."

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